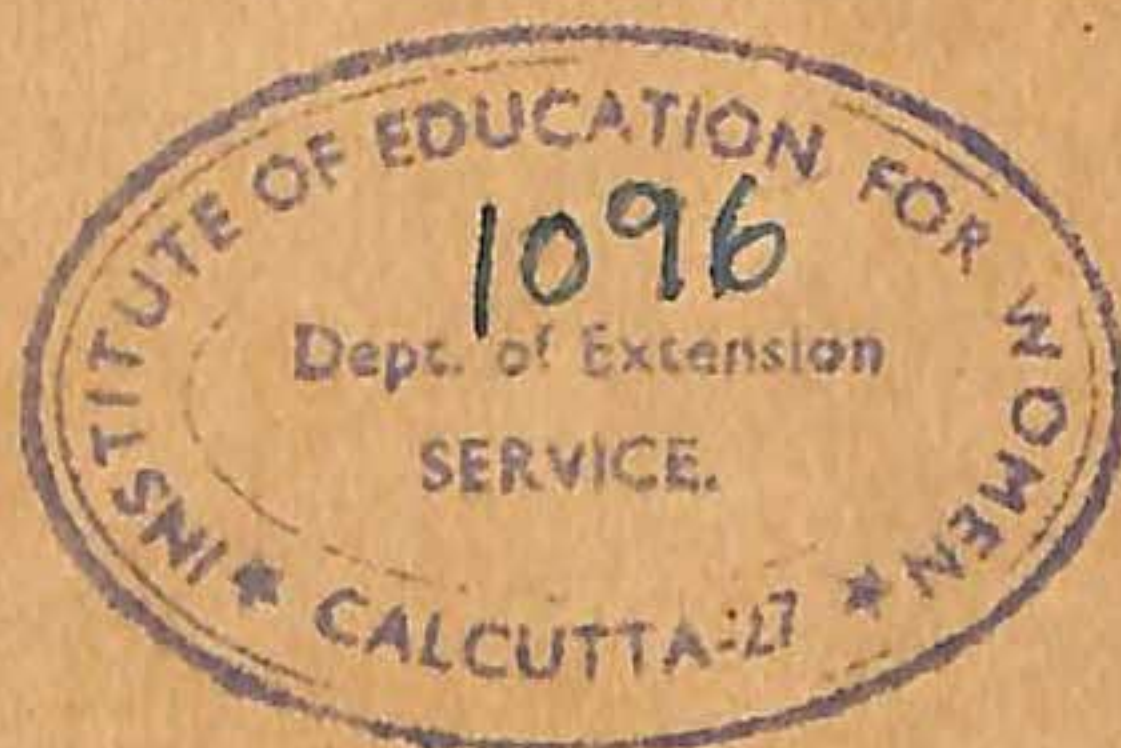


A. Atkinson and F. Daniel

GENERAL SCIENCE WORKBOOK

for Tropical Schools

Book I



Oxford University Press

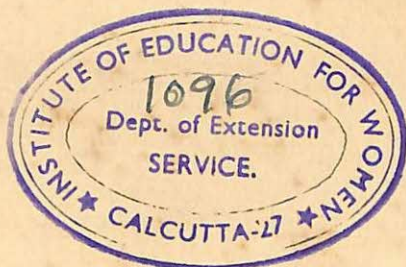
GENERAL SCIENCE WORKBOOK

for Tropical Schools

by

A. ATKINSON *and* F. DANIEL

BOOK I



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PREFACE

THE aim of these workbooks is to help General Science students towards mastery of the subject through testing their own knowledge of essential facts, principles, and methods. For many years the authors have made extensive use of this type of learning exercise, while teaching science classes which were so large that correction of essay-type homework-exercises and individual questioning in class left little time for other teaching activities. Under such circumstances it became necessary to evolve learning exercises that would help students to help themselves, and, as this 'self-testing' material has been so successful in the authors' own classes, it is now made available to others in the belief that it will be equally helpful.

It is to be emphasized, however, that these self-testing learning exercises should not entirely displace the more conventional written homework and oral classwork. They should be made complementary to these well-tried methods so as to relieve the General Science teacher of some of the heavy burden which so often makes it impossible for him to devote adequate time to preparing his own demonstration experiments and to organizing individual laboratory work for his students.

Although these learning exercises are suitable for all students of General Science, the various topics have been arranged to follow the sequence adopted in *GENERAL SCIENCE FOR TROPICAL SCHOOLS*—written by one of us (F. D.) and also published by the Oxford University Press—so as to make these text-books and workbooks complementary. This first workbook goes with Books I and II of *General Science for Tropical Schools* and the second workbook goes with Books III and IV. The workbooks, like the text-books, adequately cover the General Science syllabuses of the various external examining bodies for the Oversea School Certificate and the General Certificate of Education. We thank the Local Examinations Syndicate of the University of Cambridge for permission to include a few questions set in their examinations.

In each Section the exercises present varying degrees of difficulty, and, while all these exercises have been completed unaided by bright pupils, teachers will find it necessary to help others, individually or collectively, when they come to the more difficult exercises. Every student, however, should be encouraged to regard them as 'self-testing' exercises which he can do for himself if he uses his text-book intelligently. The teacher, of course, should go through the exercises in class as the

PREFACE

students complete each section, with the students checking their own exercises and asking questions when necessary. In this way, profitable class-discussion will be stimulated; in fact, some of the exercises have been designed with this object in mind.

In those parts of the subject which lend themselves to mathematical treatment, the workbooks provide the student with that practice in solving simple numerical problems which experience has shown to be necessary if the application of scientific principles is to be understood. The provision of specimen worked examples of each type of problem, it is hoped, will leave the teacher with more time to help students with their individual difficulties when they reach the harder problems towards the end of each chapter.

Considerations of cost have made it necessary to exclude the useful type of learning exercise based on completing or labelling drawings and diagrams. Such drawings and diagrams, however, can be produced more cheaply on the school duplicator than in a printed book.

A. A.

F. D.

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TO THE STUDENT—HOW TO USE THIS WORKBOOK

If you use this book properly and work systematically through these learning and testing exercises it will help you to master the subject. You should first do the 'Exercises', in order, after the corresponding topics have been dealt with in class. Then, if you have time (or if you are taking General Science as a double subject in the School Certificate Examination), go on to the 'Additional Exercises'. The learning exercises are designed to ensure that you know the most important facts and principles which have been discussed by your teacher in science lessons and which you have read about in your text-books. The numerical problems give you practice in applying these facts and principles, thus helping you to understand and remember them. If you are unable to complete any particular exercise, then you should consult the text-book, thus revising the weak spots in your knowledge. This workbook will also be useful during your final revision for the School Certificate Examination.

Many of the exercises can be completed by writing a few words in the spaces provided in the workbook, but in order to save paper (and thus reduce the cost of the book) the longer answers and the numerical problems are to be written in a separate exercise book. You are told how many lines you ought to write to supply the information required by these longer questions, writing your answers as *complete sentences*.

When using this book, remember that these are primarily *self-learning* and *self-testing* exercises. Your teacher supplies the *teaching*, but *you* have to do the *learning*.

CHAPTER I

THE AIR. MATTER. THE GASES OF THE AIR

EXERCISE 1. To be completed after studying Chapters I, II, and III of
General Science for Tropical Schools, Book I.

1. Air contains about 78% of and about 21% of
2. The ash formed when magnesium burns in air is in colour and weighs than the original magnesium.
3. Two impurities commonly present in a specimen of nitrogen obtained from air are and
4. Name four gases present in the atmosphere.....
5. Name two natural processes in which carbon dioxide is set free.
6. Name two substances which when heated by themselves give off oxygen.
7. Describe what you would see when (i) crystals of copper sulphate are gently heated in a test-tube, (2 lines) (ii) water is added to the residue in the test-tube. (1 line)
8. When water will dissolve no more salt it is said to be
9. Sodium burns in air with a flame to form a powder called This powder dissolves in water to form and the solution turns litmus

10. Sulphur burns in oxygen with a flame to form a called This dissolves in water to form, which turns litmus

11. State, with a reason in each case, whether each of the following substances would (a) increase in weight or (b) decrease in weight, or (c) remain unchanged in weight when heated in air:—

Copper
Potassium chlorate
Potassium permanganate
Magnesium oxide

12. State, with a reason in each case, whether each of the following would (a) increase in weight or (b) decrease in weight, or (c) remain unchanged in weight when left in the air for some time:—

Calcium chloride
Iron filings
Anhydrous copper sulphate
Nichrome wire

13. The oxides of metals are oxides, and those that are soluble in water form, which turn litmus Most non-metals form oxides, but the non-metal forms a neutral oxide called

14. Give three reasons for thinking that breathing and burning are similar chemical changes. (3 lines)

15. Name two chemical compounds formed during the burning of a candle.
.....

16. Give two examples of physical changes and two examples of chemical changes which take place during the burning of a candle.

Physical
Physical
Chemical
Chemical

17. What products result from burning each of the following in oxygen, and what is the action of water on each of these products?

Phosphorus

Calcium

Iron.....

18. Petrol will dissolve the following three substances

19. Everything that occupies space and possesses weight is included in the general term

20. The products formed when a candle burns in air weigh than the original candle.

21. State two properties of air which suggest that it is a mixture and not a compound. (2 lines)

22. Copper sulphate is soluble in cold water than in hot water.

Carbon dioxide is soluble in cold water than in hot water.

23. What common name is given to each of the following substances?

Hydrated sodium carbonate

Potassium nitrate

Sodium chloride

24. The elements present in mercuric oxide are
.....; those present in potassium nitrate are
.....; and those present in copper sulphate crystals are

25. What colours are the following substances? (a) manganese dioxide
....., (b) potassium chlorate, and (c) oxygen

26. When mercuric oxide is heated it forms a coloured liquid called and gives off a called
..... This change is a change.

27. State whether each of the following substances is an element, a compound, or a mixture.

Soil

Air

Oxygen

Sulphuric acid

Magnesium.....

Brine

Lime-water.....

Water

28. State two natural processes which remove carbon dioxide from the atmosphere.....

29. Give one example of the use of oxygen (i) in shipbuilding, (ii) in hospitals, (iii) in aeroplanes.

(i).....

(ii).....

(iii).....

30. Name two rare gases present in the atmosphere and give one use of each.
(2 lines)

31. Give two reasons for saying that rusting and burning are similar chemical changes. (2 lines)

32. Name one solvent for each of the following:

Fat..... Motor oil

Sulphur..... Shellac.....

Road tar..... Slaked lime.....

33. What are the chemical names for (i) Active air?
(ii) Inactive air?, (iii) Fixed air?
....., (iv) Magnesium ash?
(v) Quick lime?

34. Iron rusts only when both and are present.

35. Why is helium the most suitable gas for filling balloons and airships?
(1 line)

36. Complete the following chemical statements:—

..... + ... → Carbon Dioxide

..... → Oxygen + ...

Magnesium + Oxygen →

..... + Oxygen → Mercuric

Iron + ... → Iron Sulphide.

Quicklime + Water →

37. Name six elements.....

38. Desiccators usually contain the white solid
39. State the usual tests for the following substances: (i) oxygen, (1 line)
(ii) carbon dioxide. (1 line)
40. What is an element? (2 lines)
41. Underline the chemical changes in the following list:—sugar dissolving; a fire-cracker exploding; the wire inside an electric bulb becoming white-hot.
42. What colours are (i) anhydrous cobalt chloride?
(ii) cobalt chloride crystals?
43. In what four ways are mixtures different from compounds? (4 lines)
44. Outline briefly the commercial preparation of oxygen from liquid air. (3 lines)

CHAPTER II

PLANT LIFE

EXERCISE 2. To be completed after studying Chapter IV of
General Science for Tropical Schools, Book I.

1. On which part of the root are most of the root hairs found? (1 line)
2. State three conditions necessary for the germination of seeds. (2 lines)
3. Germinating seeds use up from the air and give back
.....
4. Name three flowering plants that have the following types of storage organ.
Bulb
Corm
Tuber
5. Why do many plants fail to grow after transplanting? (1 line)
6. Name the three main parts of a flowering plant. (1 line)

7. Of what use are its seed-leaves (cotyledons) to the bean seedling? (1 line)
How would you prove that your answer is correct? (2 lines)
8. What are the two main uses of roots to plants? (2 lines)
9. What is dissolved in the sap of a plant?
10. Water enters root hairs by a process called
11. What is the use of green leaves to a plant? (1 line)
12. State two differences between seedlings grown in the dark and those grown in the light. (2 lines)
13. What do stems do for plants? (2 lines)
14. What does a root-cap do for a plant? (1 line)
15. Where does growth in length take place in the root? (1 line)
16. What is meant by germination? (2 lines)
17. What is the effect of gravity on roots? (1 line)
18. Explain why an English potato is considered to be a stem. (1 line)
19. What are the three chief ways in which plants climb? Give a named example of each. (2 lines)
20. Mention two differences between an underground stem and a true root? (2 lines)
21. How would you tell whether a plant was a mono-cotyledon or a di-cotyledon when you are unable to examine its seeds? (2 lines)
22. Name two plants which have fibrous roots.
23. What kind of roots are produced by plants having only one seed-leaf?
24. What kind of underground stem has each of the following plants?

Ginger	Sweet potato
Lalang	Crinum Lily

25. Name the way in which each of the following plants climbs.

Rattan	Pepper
Bean	Melon

CHAPTER III

WATER

EXERCISE 3. To be completed after studying Chapter V of
General Science for Tropical Schools, Book I.

1. In the electrolysis of water is added to the water to make it conduct electricity. is set free at one electrode and at the other.
2. When water evaporates it changes from the state to the state.
3. Is water an element, a compound, or a mixture?
4. Hydrogen can be used to fill balloons and airships because.....
.....
5. Why is it dangerous to use hydrogen for filling passenger balloons? (1 line)
Name a gas which is better than hydrogen for this purpose.
6. Why does boiling make some kinds of water safer to drink? (2 lines)
7. In distillation the process of is followed by the process of
8. Calcium reacts with water to form the gas The product left dissolved in the liquid is
....., which turns neutral litmus solution from to
9. Name one gas which will burn in air Name two gases which will not burn in air

10. Why is chlorine often added to the water supply of a city? (1 line)
11. The purest kind of natural water is
12. Mention two natural processes which add water to the atmosphere. (1 line)
13. Why is the water from a deep well less likely to be harmful to drink than water from a shallow well? (1 line)
14. Name the two substances commonly used for preparing hydrogen in the laboratory. and
..... Which of these two substances supplies the hydrogen?
.....
15. Steam reacts with heated iron to form the gas..... and the solid.....
16. Hydrogen burns in air. It combines with the to form
17. What is meant when a substance is described as 'pure'? (2 lines)
18. State four commercial uses of hydrogen. (2 lines)
19. Why will a fish die if placed in water which has been boiled and then allowed to cool? (2 lines)
20. Oxygen is soluble in cold water than in hot water.
21. Name a substance that will act as a catalyst in the reaction between zinc and sulphuric acid.
22. Name two gases that are only slightly soluble in cold water.
..... and
23. Three gases that have no action on litmus are
....., ... and
One gas which turns litmus red is
24. Petrol is obtained from raw petroleum by the process of
25. Water turns anhydrous copper sulphate
and anhydrous cobalt chloride
26. Name one chemical which will remove water vapour from moist hydrogen.
.....

27. Complete the following chemical statements:—

Zinc + ... → + Zinc Sulphate.

..... + ... → Water.

Water + Calcium → + ...

.....
Steam + ... → + Iron Oxide.

..... + Water → Oxygen + ...

.....
Hydrochloric Acid + Iron → + ...

28. Water boils at ° C. and freezes at ° C.

29. 1 gram is the weight of 1 c.cm. of at ° C.

30. The four chief sources of water in nature are (2 lines)

31. Lime-water is made by adding or
..... or to water.

32. Oils such as palm oil and whale oil combine with hydrogen to form
....., which are used for

33. Why does spring-water contain no suspended matter? (2 lines)

34. Name two diseases caused by the presence of bacteria in drinking water.
.....

35. Why is platinum used for the electrodes in the electrolysis of water? (1 line)

36. How has your household water-supply been made safe for drinking? (3 lines)

37. Why is it dangerous to rely on the taste and appearance of water in deciding whether it is safe to drink? (2 lines)

38. Mention one way in which rain-water differs from spring-water. (1 line)

39. List four differences between the actions on water of sodium and of calcium.
(4 lines)

CHAPTER IV

DENSITY, RELATIVE DENSITY, SPECIFIC GRAVITY

To be studied at the same time as the first 23 pages of Chapter VI in
General Science for Tropical Schools, Book I.

§1. Useful definitions and facts

The *weight* of an object is the force (or pull) of the earth upon it.

The *metre* is the distance between two marks on a certain bar of metal (platinum-iridium) kept near Paris.

The *yard* is the distance between two marks on a certain bar of metal (bronze) kept in London.

The *pound* is the weight of a certain cylinder of metal (platinum) kept in London.

The *gram* is the weight of one cubic centimetre of pure water at 4° C.

The *litre* is the volume of a cube whose sides are one-tenth of a metre long.

The *gallon* is the volume of 10 pounds of distilled water at 62° F.

1 litre (l.)	= 1 cubic decimetre (c.dm.) = 1,000 cubic centimetres (c.cm.)
1 inch (in.)	= 2.54 centimetres
1 foot (ft.)	= 30.5 centimetres
1 yard (yd.)	= 0.9 metre
1 mile	= 1.6 kilometres
1 kilogram (kg.)	= 2.2 pounds (lb.)
1 pound	= 454 grams = 0.454 kilogram.

The following are some important formulae which are often required in science problems:—

Circumference of a circle	= $2\pi \times \text{radius}$ or $\pi \times \text{diameter}$
Area of a rectangle	= length $\times$ breadth
Area of a circle	= $\pi \times \text{radius}^2$
Curved surface of a cylinder	= $2\pi \times \text{radius} \times \text{length}$
Surface of a sphere	= $4\pi \times \text{radius}^2$
Volume of a rectangular block	= length $\times$ breadth $\times$ height
Volume of a cylinder	= height $\times \pi \times \text{radius}^2$
Volume of a sphere	= $\frac{4}{3}\pi \times \text{radius}^3$

§2. Density

The *density* of a substance is the weight of unit volume of the substance.

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}} \quad \text{or} \quad \text{Weight} = \text{Volume} \times \text{Density}$$

In scientific work densities are usually expressed in grams per cubic centimetre (gm. per c.cm.). In the British system densities are usually expressed in pounds per cubic foot (lb. per c.ft.).

Example 1. 20 c.cm. of a substance weigh 100 grams. Find its density.

$$\begin{aligned}\text{Density} &= \frac{\text{Weight}}{\text{Volume}} = \frac{100 \text{ gm.}}{20 \text{ c.cm.}} \\ &= 5 \text{ gm. per c.cm.}\end{aligned}$$

Example 2. The density of paraffin wax is 0.90 gm. per c.cm. Find the volume of 81 grams of the wax.

$$\begin{aligned}\text{Volume} &= \frac{\text{Weight}}{\text{Density}} = \frac{81 \text{ grams}}{0.9 \text{ gm. per c.cm.}} \\ &= 90 \text{ c.cm.}\end{aligned}$$

Example 3. The density of water is 62.5 pounds per cubic foot. What is the weight of one cubic yard of water?

$$\begin{aligned}\text{Weight} &= \text{Volume} \times \text{Density} \\ &= 27 \text{ c.ft.} \times 62.5 \text{ pounds per c.ft.} \\ &= 1,687.5 \text{ pounds.}\end{aligned}$$

Example 4. The density of water is 1.0 gm. per c.cm. Prove that it is also 62.5 pounds per cubic foot.

$$\begin{aligned}\text{Density of water} &= 1.0 \text{ gm. per c.cm.} \\ &= \frac{1.0}{454} \text{ lb. per c.cm.} \\ &= \frac{1.0}{454} \times 2.54^3 \text{ lb. per c.in} \\ &= \frac{1.0}{454} \times 2.54^3 \times 12^3 \text{ lb. per c.ft.} \\ &= 62.5 \text{ pounds per cubic foot.}\end{aligned}$$

Example 5. The density of a metal is 500 pounds per cubic foot. What is its density in grams per c.cm.?

$$\begin{aligned}
 \text{Density of metal} &= 500 \text{ lb. per c.ft.} \\
 &= 500 \times 454 \text{ grams per c.ft.} \\
 &= \frac{500 \times 454}{30.5^3} \text{ grams per c.cm.} \\
 &= 8 \text{ grams per c.cm.}
 \end{aligned}$$

DENSITIES OF SOME COMMON SUBSTANCES

SUBSTANCE	DENSITY (in grams per c.cm.)
Air	0.001165 (at 30° C. and 1 atmosphere)
Alcohol	0.83
Brass	8.5
Copper	8.9
Cork	0.25
Glass	2.6
Glycerine	1.3
Gold	19.3
Hydrogen	0.09 (at 0° C. and 1 atmosphere)
Ice	0.92
Iron	7.5
Lead	11.4
Mercury	13.6
Milk	1.03
Paraffin oil	0.8
Petrol	0.7
Turpentine (wood)	0.87
Water	1.0
Zinc	7.2

The density of water in the British system is 62.5 pounds per cubic foot.

Example 6. What is the weight of a column of mercury 76 cm. high and 1 square cm. cross-section?

$$\begin{aligned}
 \text{Volume of mercury} &= \text{Height} \times \text{Cross-section} \\
 &= 76 \text{ cm.} \times 1 \text{ sq. cm.} \\
 &= 76 \text{ c.cm.}
 \end{aligned}$$

Density of mercury is 13.6 gm. per c.cm.

$$\begin{aligned}\text{Weight} &= \text{Volume} \times \text{Density} \\ &= 76 \text{ c.cm.} \times 13.6 \text{ gm. per c.cm.} \\ &= 1,033.6 \text{ grams.}\end{aligned}$$

Example 7. A metal cylinder is 15 in. high and weighs 330 lb. Calculate its diameter if its density is 0.7 lb. per c.in.

$$\begin{aligned}\text{Volume} &= \frac{\text{Weight}}{\text{Density}} = \frac{330 \text{ lb.}}{0.7 \text{ lb.}} \text{ per c.in.} \\ \text{Cross-section of cylinder} &= \frac{\text{Volume}}{\text{Height}} \\ &= \frac{330}{0.7} \times \frac{1}{15} \text{ sq. in.} \\ &= \frac{220}{7} \text{ sq. in.}\end{aligned}$$

But the cross-section of a cylinder is $\pi \times \text{radius}^2$
Therefore,

$$\frac{22}{7} \times \text{radius}^2 = \frac{220}{7} \text{ sq. in.}$$

$$\text{Radius}^2 = 10 \text{ sq. in.}$$

$$\text{Radius} = 3.162 \text{ in.}$$

$$\text{Diameter of cylinder} = 6.324 \text{ in.}$$

i.e.

PROBLEMS ON DENSITY

[Use the densities given in the table in paragraph 2 when necessary. Take π as $\frac{22}{7}$.

Remember that 1 gm. per c.cm. is 62.5 lb. per c.ft.]

1. Calculate the densities of the following substances:—

- (a) Wood. 250 c.cm. of wood weigh 190 gm.
- (b) Copper sulphate solution. 500 c.cm. of solution weigh 515 gm.
- (c) Brick. A brick 10 in. $\times$ 5 in. $\times$ 3 in. weighs 7 lb.
- (d) Copper. 9 c.cm. of copper weigh 81 gm.
- (e) Brass. A block 2 ft. $\times$ 2 ft. $\times$ 1 ft. weighs 2,000 lb.

2. Calculate the weights of the following:—

- (a) 1 litre of turpentine.
- (b) 95 c.cm. of mercury.
- (c) A 2 cm. cube of lead.
- (d) A ball of ice with radius 1 cm.
- (e) The petrol in a cylinder 2 ft. high and 1 ft. diameter.
- (f) The water filling a tank size 3 ft. $\times$ 2 ft. $\times$ $1\frac{1}{2}$ ft.

3. Calculate the volumes of the following:—

- | | |
|----------------------------|-----------------------------------|
| (a) 10 grams of glycerine. | (e) 10 grams of air at 30° C. and |
| (b) 500 grams of alcohol. | 1 atmosphere pressure. |
| (c) 1 kilogram of petrol. | (f) 5 lb. of ice. |
| (d) 1 kilogram of mercury. | (g) 5 lb. of water. |
| | (h) 5 grams of brass. |

4. A beaker weighs 50 gm. when empty. What will it weigh when it contains
(a) 50 c.cm. of water, (b) 50 c.cm. of mercury, (c) 40 c.cm. of petrol?

5. A piece of lead weighing 114 gm. was added to water in a graduated cylinder. The height of the water-level before adding the lead was 24 c.cm. What was the height of the water-level after adding the lead?

6. The density of a metal is 700 lb. per c.ft. What is its density in grams per c.cm.?

7. A rectangular block of iron weighs 50 kilograms. Its length is 1 metre and its breadth 50 cm. What is its depth in cm.?

8. A flask weighed $\frac{1}{2}$ lb. when empty and 2 lb. when it contained some water. What would it weigh if it contained the same volume of mercury?

9. What is the weight in (a) pounds and (b) grams of a column of mercury 30 in. high and 1 sq. in. cross-section?

10. What is the weight in (a) pounds and (b) grams of a column of water 34 ft. high and 1 sq. in. cross-section?

11. A bottle weighs x grams when empty and y grams when full of water. What is the volume of the bottle?

12. A coil of iron wire weighed 220 grams. The diameter of the wire was 2 mm. What was the length of wire in the coil?

13. 25 c.cm. of sea water were added to a beaker weighing 25 gm. The total weight was now 52.5 gm. What was the density of the sea-water?

§3. Specific gravity or relative density

The *specific gravity or the relative density* of a substance is the number of times the substance is as dense as water.

$$\text{Specific Gravity or Relative Density} = \frac{\text{Density of the substance}}{\text{Density of water}}$$

Since the specific gravity or relative density is only a ratio it is expressed merely as a number, e.g. the specific gravity of lead is 11.4.

In the metric system the specific gravity or relative density of a substance is the same number as its density in grams per c.cm., e.g. the specific gravity of brass is 8.5 and the density of brass is 8.5 gm. per c.cm.

In the British system the two numbers are not the same, e.g. the specific gravity of water is 1 and its density is 62.5 lb. per c.ft.

Example 8. The density of mercury is 13.6 gm. per c.cm. What is its specific gravity?

$$\begin{aligned}\text{Specific gravity} &= \frac{\text{Density of mercury}}{\text{Density of water}} \\ &= \frac{13.6 \text{ gm. per c.cm.}}{1.0 \text{ gm. per c.cm.}} \\ &= 13.6.\end{aligned}$$

Example 9. The density of glass is 162.5 lb. per c.ft. What is its relative density?

$$\begin{aligned}\text{Relative density} &= \frac{\text{Density of glass}}{\text{Density of water}} \\ &= \frac{162.5 \text{ lb. per c.ft.}}{62.5 \text{ lb. per c.ft.}} \\ &= 2.6.\end{aligned}$$

§4. A second formula for specific gravity or relative density is:—

$$\text{Specific Gravity or Relative Density} = \frac{\text{Weight of the substance}}{\text{Weight of an equal volume of water}}$$

Proof:

By definition,

$$\begin{aligned}\text{Specific gravity} &= \text{Density of substance} \div \text{Density of water} \\ &= \frac{\text{Weight of substance}}{\text{Volume of substance}} \div \frac{\text{Weight of water}}{\text{Volume of water}} \\ &= \frac{\text{Weight of substance}}{\text{Weight of equal volume of water}}\end{aligned}$$

Example 10. A specific gravity bottle weighed 20 gm. empty, 45 gm. when full of water, and 40 gm. when full of paraffin oil. Calculate the specific gravity of paraffin oil.

$$\begin{aligned}\text{Weight of water in bottle} &= 45 - 20 = 25 \text{ gm.} \\ \text{Weight of paraffin oil in bottle} &= 40 - 20 = 20 \text{ gm.}\end{aligned}$$

$$\begin{aligned}\text{Specific gravity of oil} &= \frac{\text{Weight of oil}}{\text{Weight of equal volume of water}} \\ &= \frac{20 \text{ gm.}}{25 \text{ gm.}} \\ &= 0.8.\end{aligned}$$

Example 11. An empty beaker weighs 28 gm. If it weighs 48 gm. when it contains water what will it weigh when it contains the same volume of petrol (specific gravity 0.7)?

$$\text{Weight of water} = 48 - 28 = 20 \text{ grams.}$$

$$\begin{aligned}\text{Weight of petrol} &= \text{Specific gravity of petrol} \times \text{weight of equal volume of water} \\ &= 0.7 \times 20 \text{ grams} \\ &= 14 \text{ grams.}\end{aligned}$$

Therefore,

$$\begin{aligned}\text{Weight of beaker plus petrol} &= 28 + 14 \text{ grams} \\ &= 42 \text{ grams.}\end{aligned}$$

Example 12. The specific gravity of lead is 11.4. The density of water is 62.5 lb. per c.ft. What is the density of lead?

$$\begin{aligned}\text{Density of lead} &= \text{Specific gravity of lead} \times \text{Density of water} \\ &= 11.4 \times 62.5 \text{ lb. per c.ft.} \\ &= 712.5 \text{ lb. per c.ft.}\end{aligned}$$

Example 13. What is the volume in cubic feet of 3 lb. of cork? (Relative density of cork is 0.25; density of water is 62.5 lb. per c.ft.).

FIRST METHOD

$$\text{Relative density of cork} = \frac{\text{Weight of cork}}{\text{Weight of equal volume of water}}$$

$$0.25 = \frac{3 \text{ lb.}}{\text{Weight of equal volume of water}}$$

Therefore, $0.25 = \frac{3 \text{ lb.}}{\text{Weight of equal volume of water}}$

i.e. $\text{Weight of water} = \frac{3 \text{ lb.}}{0.25}$
 $= 12 \text{ lb.}$

But 62.5 lb. of water occupy 1 c.ft.

Therefore, 12 lb. of water occupy $\frac{12}{62.5}$ c.ft., i.e. $\frac{24}{125}$ c.ft.

i.e. $\text{Volume of 3 lb. of cork is } \frac{24}{125} \text{ c.ft.} = 0.192 \text{ c.ft.}$

SECOND METHOD

$$\text{Relative density of cork} = \frac{\text{Density of cork}}{\text{Density of water}}$$

i.e. $\text{Density of cork} = \text{Density of water} \times \text{Relative density}$
 $= 62.5 \text{ lb. per c.ft.} \times 0.25$
 $= \frac{125}{8} \text{ lb. per c.ft.}$

Therefore, $\frac{125}{8}$ lb. of cork occupy 1 c.ft.

i.e. $3 \text{ lb. of cork occupy } \frac{3 \times 8}{125} \text{ c.ft.}$
 $= \frac{24}{125} \text{ c.ft.} = 0.192 \text{ c.ft.}$

Example 14. A beaker weighed 24 gm. when empty and 65.6 gm. when full of turpentine (specific gravity 0.8). What was the volume of the beaker?

$$\text{Volume of turpentine} = \frac{\text{Weight}}{\text{Density}} = \frac{65.6 - 24}{0.8} = \frac{41.6 \text{ gm.}}{0.8 \text{ gm. per c.cm.}}$$

$$= 52 \text{ c.cm.}$$

Therefore, volume of beaker is 52 c.cm.

Example 15. 62.7 gm. of lead shot were placed in a 50 c.cm. specific gravity bottle. The bottle was now filled with water from a burette, and 44.5 c.cm. of water were needed. Calculate the density of lead.

$$\text{Volume of the lead} = 50 - 44.5 \text{ c.cm.} = 5.5 \text{ c.cm.}$$

$$\begin{aligned}\text{Density of lead} &= \frac{\text{Weight}}{\text{Volume}} = \frac{62.7 \text{ grams}}{5.5 \text{ c.cm.}} \\ &= 11.4 \text{ gm. per c.cm.}\end{aligned}$$

Example 16. A tank holds 2,550 lb. of sea-water of relative density 1.02. What is the volume of the tank? (Density of pure water is 62.5 lb. per c.ft.)

$$\text{Relative density of sea-water} = \frac{\text{Density of sea-water}}{\text{Density of water}}$$

$$\begin{aligned}\text{i.e.} \quad \text{Density of sea-water} &= \text{Relative density} \times \text{Density of water} \\ &= 1.02 \times 62.5 \\ &= 63.75 \text{ lb. per c.ft.}\end{aligned}$$

$$\begin{aligned}\text{Volume of sea-water} &= \frac{\text{Weight}}{\text{Density}} \\ &= \frac{2,550 \text{ lb.}}{63.75 \text{ lb. per c.ft.}} \\ &= 40 \text{ c.ft.}\end{aligned}$$

Volume of tank is 40 c.ft.

PROBLEMS ON SPECIFIC GRAVITY

[In the following problems take the density of water as 62.5 lb. per c.ft. unless otherwise stated.]

14. A hole 10 ft. long, 5 ft. deep, and 2 ft. wide is filled with soil of specific gravity 2. What weight of soil fills the hole?

15. A petrol tank is 10 metres high and 2 metres in diameter. It contains petrol of specific gravity 0.70. What is the weight of the petrol?

16. 50 cm. of copper wire (relative density 8.9) weighed 4.45 grams. Calculate the cross-section of the wire.

17. 24 inches of steel wire of cross-section 0.2 square inches weigh 1.25 lb. What is the relative density of the steel?

18. Calculate the specific gravities of the liquids, A, B, and C from the following experimental results:—

Weight of empty specific gravity bottle	= 24.62 gm.
„ „ bottle full of water	= 74.62 gm.
„ „ „ „ „ liquid A	= 73.35 gm.
„ „ „ „ „ B	= 77.12 gm.
„ „ „ „ „ C	= 95.34 gm.

19. A specific gravity bottle weighed 20.4 gm. when empty and 45.4 gm. when full of water. What does it weigh when full of (a) mercury (specific gravity 13.6), (b) milk (specific gravity 1.03), and (c) petrol (specific gravity 0.7)?

20. A glass tube contained a column of mercury 15 cm. long. The mercury was weighed and its weight was 1.496 gm. Calculate the average internal diameter of the glass tube. (Specific gravity of mercury is 13.6.)

21. A large jar weighed 12 lb. when empty and 87 lb. when full of water. Find the volume of the jar.

22. Calculate the weight of a glass window 1 metre high, $\frac{1}{2}$ metre wide, and 4 mm. thick. (Specific gravity of glass is 2.6.)

23. A sheet of steel (relative density 8) is 1 yard long, $\frac{1}{2}$ yard wide, and 0.4 inches thick. Calculate its weight.

24. Calculate the weight of air in a room 10 metres long, 7 metres wide, and 10 metres high. (Specific gravity of air is 0.0012.)

HARDER EXAMPLES ON DENSITY AND SPECIFIC GRAVITY

Example 17. Zinc (specific gravity 7.2) and copper (specific gravity 8.9) are mixed in equal volumes to form an alloy of weight 80.5 gm. What are the volume and the weight of the copper used?

Let the volume of the copper used be V c.cm.

Therefore,

$$\begin{aligned}\text{Weight of the copper used} &= \text{Volume} \times \text{Density} \\ &= V \text{ c.cm.} \times 8.9 \text{ gm. per c.cm.} \\ &= 8.9V \text{ gm.}\end{aligned}$$

Similarly,

$$\text{Weight of zinc used} = 7.2V \text{ gm.}$$

Therefore,

$$\text{Total weight of alloy} = 8.9V + 7.2V \text{ gm.}$$

i.e. $80.5 \text{ gm.} = 16.1V \text{ gm.}$

i.e. $V = \frac{80.5}{16.1} \text{ c.cm.}$
 $= 5 \text{ c.cm.}$

Volume of copper used is 5 c.cm.

Weight of copper used is $8.9 \times 5 = 44.5 \text{ gm.}$

Example 18. It is desired to make 100 c.cm. of an alloy of copper (specific gravity 8.9) and brass (specific gravity 8.5). What volumes of copper and brass are required if the density of the alloy is to be 8.6 gm. per c.cm.?

The weight of 100 c.cm. of alloy of density 8.6 gm. per c.cm. is

$$100 \times 8.6 = 860 \text{ grams.}$$

Let the volume of the copper be V c.cm. Therefore its

$$\text{Weight} = \text{Volume} \times \text{Density} = 8.9V \text{ grams.}$$

The volume of the brass must be $100 - V$ c.cm. and its weight is therefore $(100 - V) \times 8.5$ grams.

$$\text{Weight of copper} + \text{Weight of brass} = \text{Weight of alloy}$$

$$8.9V + 8.5(100 - V) = 860$$

$$8.9V + 850 - 8.5V = 860$$

$$0.4V = 10$$

$$V = 25 \text{ c.cm.}$$

Volume of copper is 25 c.cm. and volume of brass 75 c.cm.

Example 19. A specific gravity bottle weighs 20.08 gm. empty and 70.24 gm. when full of water. Some sand is placed in the empty bottle and the total weight of sand and bottle is 32.40 gm. The bottle is then filled up with water and it weighs 77.34 gm. What is the density of the sand?

$$\text{Weight of water to fill the bottle is } 70.24 - 20.08 = 50.16 \text{ gm.}$$

$$\text{Weight of sand in the bottle is } 32.40 - 20.08 = 12.32 \text{ gm.}$$

$$\text{Weight of water now required to fill the bottle is } 77.34 - 32.40 = 44.96 \text{ gm.}$$

Therefore 12.32 gm. of sand occupy the same volume as $50.16 - 44.96$, i.e. 5.20 gm. of water.

$$\begin{aligned}
 \text{Specific gravity of sand} &= \frac{\text{Weight of sand}}{\text{Weight of equal volume of water}} \\
 &= \frac{12.32 \text{ gm.}}{5.20 \text{ gm.}} \\
 &= 2.37
 \end{aligned}$$

Therefore density of sand is 2.37 gm. per c.cm.

HARDER PROBLEMS ON DENSITY AND SPECIFIC GRAVITY

25. A flask contains a little water. The water is boiled, the flask is then corked, cooled, and weighed. Its weight is 80.27 gm. The flask is now opened and weighed, and its weight is 80.57 gm. 240 c.cm. of water are now needed to fill the flask. Calculate the density of air.

26. The experiment described in problem No. 25 was repeated. The corked flask weighed 79.46 gm. and required 300 c.cm. of water to fill it. What was the weight of the flask when it was opened and weighed just before the water was added? (Density of air 1.16 gm. per litre.)

27. A piece of cork (specific gravity 0.25) was tied to 7.5 c.cm. of glass, and the average density of the two was 1 gm. per c.cm. What was the weight of the cork if the density of the glass was 2.5 gm. per c.cm.?

28. There are 1,639 gm. of sulphuric acid in 1 litre of acid of specific gravity 1.82. Prove that the concentration of the acid is 90 gm. per 100 gm. of solution.

29. 15 gm. of a wax of density 0.9 gm. per c.c. were melted with 25 gm. of another wax of density 0.98 gm. per c.c. Calculate the density of the mixture after it had solidified.

30. A 50 c.cm. specific gravity bottle weighs 28.0 gm. Iron filings are added until the bottle and filings weigh 103.5 gm. Water is now added until the bottle is full and the total mass is 143.5 gm. Calculate the density of the iron filings.

CHAPTER V

PRINCIPLE OF ARCHIMEDES. FLOATING

To be studied at the same time as the last eleven pages of Chapter VI of
General Science for Tropical Schools, Book I.

§5. The Principle of Archimedes states that when an object is weighed in air and then wholly or partly in a fluid (i.e. liquid or gas) the object seems to lose weight. This seeming loss in weight is equal to the weight of the fluid displaced by the object.

Seeming loss in weight of object = weight of fluid displaced by object.

The *Principle of Floating* states that a floating object displaces its own weight of the fluid in which it is floating.

Therefore, when an object floats in a fluid

Weight of floating object = Weight of fluid displaced by the object

WORKED EXAMPLES ON ARCHIMEDES' PRINCIPLE

Example 20. A piece of iron weighs 45 gm. in air and 39 gm. in water. What is the volume and the density of the iron?

Weight of water displaced by the iron = Seeming loss in weight
= 45 - 39 = 6 gm.

The volume of 6 gm. of water is 6 c.cm., therefore the volume of the iron is also 6 c.cm.

$$\text{Density of iron} = \frac{\text{Weight}}{\text{Volume}} = \frac{45 \text{ gm.}}{6 \text{ c.cm.}} = 7.5 \text{ gm. per c.cm.}$$

Example 21. A piece of copper (density 9 gm. per c.c.) weighs 90 gm. in air. What does it appear to weigh in glycerine (specific gravity 1.3)?

$$\begin{aligned}\text{Volume of copper} &= \frac{\text{Weight}}{\text{Density}} = \frac{90 \text{ gm.}}{9 \text{ gm. per c.cm.}} \\ &= 10 \text{ c.cm.}\end{aligned}$$

Therefore, the copper will displace 10 c.cm. of glycerine

$$\begin{aligned}&= 10 \times 1.3 \text{ gm. glycerine} \\ &= 13 \text{ gm.}\end{aligned}$$

The seeming loss in weight of the copper will be 13 gm.

Therefore,

$$\begin{aligned}\text{Weight of copper in glycerine} &= 90 - 13 \\ &= 77 \text{ gm.}\end{aligned}$$

Example 22. A glass stopper weighs 26 gm. in air, 16 gm. in water, and 8 gm. in sulphuric acid. What is the density of the glass and of the acid?

$$\begin{aligned}\text{Weight of water displaced by glass} &= \text{Seeming loss in weight} \\ &= 26 - 16 \text{ gm.} = 10 \text{ gm.}\end{aligned}$$

The volume of 10 gm. of water is 10 c.cm., therefore the volume of the glass is also 10 c.cm.

$$\text{Density of the glass} = \frac{\text{Weight}}{\text{Volume}} = \frac{26 \text{ gm.}}{10 \text{ c.cm.}} = 2.6 \text{ gm. per c.cm.}$$

$$\begin{aligned}\text{Weight of acid displaced by the glass} &= \text{Seeming loss in weight} \\ &= 26 - 8 \text{ gm.} = 18 \text{ gm.}\end{aligned}$$

$$\text{Density of the acid} = \frac{18 \text{ gm.}}{10 \text{ c.cm.}} = 1.8 \text{ gm. per c.cm.}$$

Example 23. A piece of cork weighs 1.25 gm. in air. It is tied to a piece of metal which weighs 8 gm. in water, and the cork and metal together weigh 4.25 gm. in water. Calculate the density of the cork.

Let the weight of the metal in air be w gm.

Then the seeming loss in weight of the metal is $w - 8$ gm.

Therefore, the metal displaces $w - 8$ gm. of water, and its volume must be $w - 8$ c.cm.

Similarly, the weight of the metal and cork in air is $w + 1.25$ gm.

Seeming loss in weight of cork and metal together is

$$(w + 1.25) - 4.25 \text{ gm.} = w - 3 \text{ gm.}$$

Therefore, volume of cork and metal is $w - 3$ c.cm.

$$\begin{aligned}\text{Therefore, volume of the cork is } (w - 3) - (w - 8) \\ = 5 \text{ c.cm.}\end{aligned}$$

$$\text{Density of cork} = \frac{\text{Weight}}{\text{Volume}} = \frac{1.25 \text{ gm.}}{5 \text{ c.cm.}} = 0.25 \text{ gm. per c.cm.}$$

PROBLEMS ON ARCHIMEDES' PRINCIPLE

31. A metal cube weighs 20 gm. in air and 16 gm. in water. What is the volume and the density of the metal?

32. A piece of wood (specific gravity 1.25) weighs 1 gm. in water. What does it weigh in air?
33. The density of brass is 8.5 gm. per c.cm. What is the apparent weight of a 100 gm. brass weight in water?
34. An object has a volume of 4 c.cm. and weighs 25 gm. in air. What does it appear to weigh (a) in water, and (b) in alcohol (density 0.8 gm. per c.cm.)?
35. A piece of iron (density 7.5 gm. per c.cm.) weighs 65 gm. in water and 67 gm. in alcohol. What is the density of the alcohol? What will be the apparent weight of the iron in glycerine (density 1.3 gm. per c.cm.)?
36. A sphere of diameter 2 ft. is made of metal of relative density 8. What will the sphere seem to weigh in water (1 c.ft. of water weighs 62.5 lb.)?
37. A glass stopper (specific gravity 2.4) weighed 19.2 gm. in air and 9.6 gm. in dilute acid. Calculate the density of the acid.
38. Prove that, if 8 c.cm. of wood (specific gravity 0.7) are tied to 100 gm. of metal of density 8 gm. per c.cm., the weight of the metal and wood in water is 85.1 gm.
39. A cube of iron weighs 43.2 gm. in alcohol (specific gravity 0.8) and 40.2 gm. in glycerine (specific gravity 1.3). Prove that the iron weighs 48 gm. in air and 42 gm. in water.
40. What volume of lead (density 11.4 gm. per c.cm.) must be tied to 60 c.cm. of wood (density 0.7 gm. per c.cm.) so that the lead and wood together shall weigh 34 gm. in water?

WORKED EXAMPLES ON FLOATING

Example 24. A block of wood weighing 1,280 lb. floats in sea-water of density 64 lb. per c.ft. What volume of the block is immersed (i.e. beneath the surface)?

$$\begin{aligned} \text{Weight of the wood} &= \text{Weight of sea-water displaced} \\ \text{i.e. } 1,280 \text{ lb.} &= \text{Volume displaced} \times \text{Density} \\ &= \text{Volume displaced} \times 64 \text{ lb. per c.ft.} \end{aligned}$$

Therefore,

$$\text{Volume of sea-water displaced is } \frac{1,280}{64} = 20 \text{ c.ft.}$$

i.e. the volume of the block immersed is 20 c.ft.

Example 25. If the block of wood in Example 24 measured 5 ft. $\times$ 3ft. $\times$ 2 ft. what is its density?

$$\text{Volume of the wood} = 5 \times 3 \times 2 \text{ c.ft.} = 30 \text{ c.ft.}$$

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}} = \frac{1,280 \text{ lb.}}{30 \text{ c.ft.}} = 42.67 \text{ lb. per c.ft.}$$

Example 26. A uniform cylinder of wood floats in water with 10 cm. of its length immersed and 5 cm. above the water. What is the specific gravity of the wood?

FIRST METHOD

Let the cross-section of the cylinder be x sq. cm.

Therefore, the volume of water displaced is $10x$ c.cm. and the weight of water displaced is $10x$ gm.

By the principle of floating

$$\begin{aligned}\text{Weight of the wood} &= \text{Weight of water displaced} \\ &= 10x \text{ gm.}\end{aligned}$$

$$\begin{aligned}\text{Specific gravity of the wood} &= \frac{\text{Weight of the wood}}{\text{Weight of an equal volume of water}} \\ &= \frac{10x \text{ gm.}}{15x \text{ gm.}} \\ &= 0.67.\end{aligned}$$

SECOND METHOD

The weight of the wood equals the mass of the water displaced (by the principle of floating).

Therefore, 10 volumes of water weigh as much as 15 volumes of wood, i.e. wood is $\frac{10}{15}$ as dense as water, i.e.

$$\text{Specific gravity of wood is } \frac{10}{15} = 0.67.$$

Example 27. The cylinder of wood in Example 26 is floated in an oil of density 0.8 gm. per c.cm. What length of the wood is immersed?

The weight of the wood is $10x$ gm. and therefore the weight of the oil displaced by the wood is $10x$ gm. (by the principle of floating).

$$\begin{aligned}\text{The weight of oil displaced} &= \text{Volume of oil displaced} \times \text{Density of oil} \\ &= \text{Length of wood immersed} \times x \times 0.8\end{aligned}$$

Therefore,

$$10x = \text{Length of wood immersed} \times x \times 0.8$$

$$\begin{aligned}\text{Length of wood immersed} &= \frac{10x}{0.8x} \\ &= 12.5 \text{ cm.}\end{aligned}$$

Example 28. A submarine just sinks in fresh water (density 62.5 lb. per c.ft.). The volume of the submarine is 5,000 c.ft. What extra weight of water must be let into the tanks so that the submarine will just sink in sea-water (specific gravity 1.03)?

By the principle of floating,

$$\begin{aligned}\text{Weight of submarine} &= \text{Weight of fresh water displaced} \\ &= \text{Volume} \times \text{Density} \\ &= 5,000 \times 62.5 \text{ lb.}\end{aligned}$$

$$\begin{aligned}\text{Density of sea-water} &= \text{Density of fresh water} \times \text{Specific gravity} \\ &= (62.5 \times 1.03) \text{ lb. per c.ft.}\end{aligned}$$

Therefore, when the submarine is in sea-water

$$\begin{aligned}\text{Weight of water displaced} &= \text{Volume of submarine} \times \text{Density of sea-water} \\ &= 5,000 \times 62.5 \times 1.03 \text{ lb.}\end{aligned}$$

Therefore, the weight of the submarine must now be $5,000 \times 62.5 \times 1.03$ lb., i.e. the extra weight of water to be let into the tanks is

$$5,000 \times 62.5 \times (1.03 - 1) \text{ lb.} = 9,375 \text{ lb.}$$

Example 29. A balloon weighs 150 gm. when empty. It is filled with 1,000 litres of hydrogen of density 0.1 gm. per litre, the density of air being 1.3 gm. per litre. What load can be lifted by this balloon?

$$\begin{aligned}\text{Weight of the hydrogen} &= \text{Volume} \times \text{Density} \\ &= 1,000 \times 0.1 = 100 \text{ gm.}\end{aligned}$$

Therefore,

$$\text{Weight of the balloon and hydrogen is } 150 + 100 = 250 \text{ gm.}$$

$$\begin{aligned}\text{The weight of air displaced by the balloon} &= \text{Volume} \times \text{Density} \\ &= 1,000 \times 1.3 = 1,300 \text{ gm.}\end{aligned}$$

When the balloon and its load float in air they appear to weigh nothing, and

$$\begin{aligned}\text{Weight of air displaced} &= \text{Seeming loss in weight} \\ 1,300 \text{ gm.} &= 250 + \text{load}\end{aligned}$$

i.e.

$$\text{Load} = 1,050 \text{ gm.}$$

PROBLEMS ON FLOATING

41. An object weighing 20 gm. floats in water. What is the volume of the water displaced?
42. An object weighing 24 gm. floats in water with two-thirds of its volume immersed in the water. What is the density and the volume of the object?
43. An object weighing 25 gm. floats in alcohol (specific gravity 0.8) with two-thirds of its volume immersed in the alcohol. What are the density and the volume of the object?
44. A uniform wooden rod is 15 cm. long and 1 cm. square. It floats in water and 10 cm. of the rod are immersed. What is the density of the wood? What length would be immersed in glycerine (specific gravity 1.34)?
45. A uniform rod floats in water with one-quarter of the rod above the water. It floats in ammonia solution with one-fifth of the rod above the solution. What are the density of the rod and the specific gravity of the solution?
46. How many cubic feet of water are displaced when a box weighing 1,000 lb. floats (a) in fresh water of density 62.5 lb. per c.ft. and (b) in sea-water of specific gravity 1.05?
47. A beaker of radius 4 cm. floats in water with 7 cm. of its depth in the water. The beaker contains lead shot. Calculate the weight of the beaker and the lead shot. What weight of lead shot must now be added to make the beaker sink another 1 cm.?
48. A ball of iron (density 7.5 gm. per c.cm.) floats in mercury (density 13.5 gm. per c.cm.). What fraction of the volume of the iron is above the mercury?
49. 5 c.cm. of wood (specific gravity 0.7) are tied to 5 c.cm. of glass (density 2.6 gm. per c.cm.). The two objects just float in a liquid. What is the specific gravity of the liquid?
50. What volume of cork (specific gravity 0.25) must be tied to 10 gm. of iron (specific gravity 7.5) so that the two objects will just float in water?
51. If the balloon described in Example 29 is filled with helium (density 0.34 gm. per litre) what is the greatest load it could lift?

52. A rectangular block of wood is 6 ft. $\times$ 4 ft. $\times$ 3 ft. and weighs 3,500 lb. It is floating in sea-water of density 64 lb. per c.ft. Calculate the smallest weight which must be placed on top of the block in order to sink it in the sea-water.

CHAPTER VI

LIMESTONE. COMMON SALT. ACIDS, BASES, AND SALTS

EXERCISE 4. To be completed after studying Chapters I, II, and III of
General Science for Tropical Schools, Book II.

1. Two substances used in the laboratory to prepare carbon dioxide are and
2. Two gases present in expired air (i.e. 'breathed-out' air) are and
3. One chemical compound that may cause temporary hardness of water is One compound that may cause permanent hardness is One substance that will remove both types of hardness is
4. Carbon dioxide is fairly soluble in cold water, forming a weak called, which turns litmus
5. What elements are present in the following compounds? (i) carbon dioxide, (1 line) (ii) limestone, (1 line) (iii) baking soda. (1 line)
6. Give three uses of slaked lime in everyday life. (2 lines)
7. State three physical properties of acids. (2 lines)

8. In what common things are the following acids met with in everyday life and for what purpose is each used?

Acetic acid
Citric acid.....
Tartaric acid

9. Two liquids in a chemical fire extinguisher may be
..... and When
mixed they react to form

10. Why is carbon dioxide foam better than water for extinguishing oil or petrol fires? (2 lines)

11. Sodium nitrate may be made by adding a solution of
acid to a solution of hydroxide until a drop of the mixture
just turns neutral litmus paper from to

12. Name the constituents in the following substances:—

Baking powder
Mortar
Whitewash
Soda water.....

13. The gas dissolves very readily
in water, forming a solution which reacts with zinc, liberating

14. Give either the chemical formula or the chemical name of:—

Chalk	Quicklime.....
Salt	Baking soda.....
Caustic Soda	Nitre
Washing soda	Marble

15. Only solutions of give a
precipitate when added to silver nitrate solution acidified with nitric acid. The
precipitate is called

Only solutions of give a pre-
cipitate when added to barium chloride solution acidified with dilute hydrochloric
acid. The precipitate is called

16. All solid react with concentrated
..... acid to form
....., a colourless gas that has a pungent smell and forms misty fumes
in damp air.

17. The chemical tests for hydrogen chloride are: (i) it causes a
film to form on a drop of a mixture of silver solution and
dilute acid held on a glass rod in the gas, and (ii) it forms
..... fumes of ammonium when a glass
rod which has been dipped in ammonium hydroxide is held in the gas.

18. When carbon dioxide is bubbled through lime-water the liquid first turns
..... owing to the formation of a precipitate of
..... When more carbon dioxide is bubbled through
the liquid it becomes again, because calcium
..... is now formed and this is
in water.

19. Burning will continue to burn in carbon
dioxide. It forms a white solid called
mixed with black particles of The white solid will dissolve in
..... acid, leaving the black
undissolved.

20. Quick-lime is manufactured by heating in a
.....

21. When a few drops of water are added to quick-lime there is a
..... sound and is seen to come off owing to the great
..... developed. The lime swells and finally crumbles to a powder called
..... This dissolves in excess of water, forming
.....

22. State two reasons why slaked lime is used to improve soils. (2 lines)

23. Outline two commercial uses of carbon dioxide. (2 lines)

24. State three ways in which carbon dioxide is continually being added to the
atmosphere. (2 lines)

25. The metals and never
react with acids to liberate hydrogen.

26. The acid never reacts with metals to give hydrogen.

27. All carbonates react with, and a colourless gas is given off that turns lime-water owing to the formation of a precipitate of

28. All common chlorides are soluble in cold water except chloride and chloride.

29. All common carbonates are insoluble in water except those of and

30. Most sulphates are soluble in water, but sulphate and sulphate are insoluble and sulphate is only sparingly soluble.

31. All nitrates are in water. All salts of sodium, potassium, and ammonium are in water.

32. When solid caustic soda is left in the air for a few minutes it first becomes, and then a of caustic soda is formed. Finally, after some days, a solid called sodium is formed by the action of the of the air.

33. Name the four commonest alkalis. (2 lines)

34. Name the chemicals you would use to prepare hydrochloric acid.

35. What is the action of concentrated sulphuric acid on starch and other carbohydrates? (2 lines)

36. Salts may be prepared by the action of an acid on (a) a metal, (b) a metallic (c) a metallic or on (d) a metallic

37. Neutralization is a reaction between and producing a and only.

38. Describe briefly how you would obtain a little carbon dioxide from milky lime-water. (2 lines)

39. When vinegar is added to baking soda the gas
 is given off.
40. When calcium bicarbonate solution is heated bubbles of
 escape and a precipitate of
 is formed.
41. The two gases given off when baking soda is heated are
 and
42. Water and baking powder react to form the gas
43. Sour milk and washing soda react to form the gas
 This shows that sour milk contains
44. Name two fruits whose juice turns blue litmus red. (1 line)
45. Water containing soluble compounds of calcium is said to be
46. Describe one chemical test to distinguish between nitric acid and hydrochloric acid. (2 lines)
47. Describe one chemical test to distinguish between sulphuric acid and nitric acid. (2 lines)
48. Complete the following chemical statements:—
 Calcium Carbonate $\rightarrow$ Calcium Oxide + ...
 Quicklime + Water $\rightarrow$
 + Carbon Dioxide $\rightarrow$ Calcium Carbonate.
 Sodium Carbonate + Nitric Acid $\rightarrow$
 + ... + ...
 Carbon Dioxide + Lime-water $\rightarrow$
 + ...
 Carbon Dioxide + Water $\rightarrow$
 Carbon Dioxide + Magnesium $\rightarrow$
 + ...
 Sulphuric Acid + Sodium Chloride $\rightarrow$
 + ...
 Hydrogen Chloride + ... $\rightarrow$ Ammonium Chloride.
 + Sodium Hydroxide $\rightarrow$
 Sodium Chloride + ...

49. The following chemical statements are typical examples of methods of preparing salts. Complete them.

Hydrochloric Acid + ... → Sodium Chloride + ...

..... + Caustic Soda → Sodium Nitrate + ...

..... + ...
..... → Ammonium Sulphate + Water.

..... + Zinc → Zinc Sulphate + ...

..... + ... → Ferrous Sulphate + Hydrogen.

Copper Oxide + ... → Copper Sulphate + ...

Calcium Carbonate + ... → Calcium Nitrate + ...

..... + Hydrochloric Acid → Calcium Chloride + ...

50. The above methods of preparing salts are examples of (i) neutralization, i.e. the action of on a, (ii) the action of an acid on or on a metallic or on a metallic

51. State three general properties of alkalis. (2 lines)

52. The gas ammonia turns litmus and forms fumes of ammonium with

53. In the flame test the substance is moistened with concentrated, a wire is dipped into the mixture and then placed in a bunsen flame. The flame is coloured by sodium salts, ... by calcium salts and by copper salts.

54. State two practical advantages and two practical disadvantages of hard water. (2 lines)

55. In limestone caves grow downwards
from the top of the cave and grow upwards
from the floor. They consist of
formed by water containing dissolved
..... dropping from the roof. Some of the
..... decomposes giving off
and leaving

56. What chemical can be used to soften (i) a bucketful of water?
....., (ii) the water in a large reservoir?

57. State one important commercial use of sodium hydroxide. (1 line)

58. Describe how you would make a solution of sodium hydroxide from washing soda (sodium carbonate) and slaked lime. (3 lines)

59. Bleaching powder is prepared by passing
for a long time over solid

60. Dilute acids react with bleaching powder to form the gas

61. Chlorine is prepared by heating concentrated
..... with

62. Lead chloride is prepared by adding
solution to solution. It is formed
as a precipitate.

63. Lead sulphate is prepared by adding
solution to solution. It is formed as a
precipitate.

64. The gas is formed by the action of alkalis on
ammonium salts.

65. How would you find out whether some water in a bottle was hard or soft?
(3 lines)

66. Temporary hardness may be distinguished from permanent hardness by
..... the water. If bubbles of the gas
..... are set free and a precipitate of
..... is formed the hardness is due to
..... and is called
hardness.

67. Most carbonates give off when heated, but carbonate and carbonate do not.

68. Name two carbonates which are soluble in water. (1 line)

69. Mention two examples of efflorescence and two of deliquescence. (2 lines)

70. Soap reacts with soluble calcium compounds to form a precipitate of which appears as a curd or scum.

71. The chemical will remove both temporary and permanent hardness. The chemical will remove temporary hardness but not permanent hardness.

72. Temporary hard water may be made by bubbling into Permanent hard water may be made by dissolving a little in water.

73. What do you observe when calcium bicarbonate solution is mixed with a little soap solution and then shaken? (2 lines)

74. Give two examples of the everyday use of bleaching powder. (2 lines)

75. Why do soldiers on active service often carry bleaching powder? (1 line)

76. Sodium hypochlorite solution is made by bubbling gas into solution. Name two everyday uses of sodium hypochlorite. (2 lines)

77. Coral is a natural form of

78. Sea-shells and snail-shells consist mainly of

79. Shells of sea animals under the action of heat and great pressure form

80. Marble is formed by the action of heat and great pressure on

81. Explain briefly the various stages in the bleaching of coloured cloth by means of bleaching powder. (3 lines)

82. Name two chemicals which will remove water vapour from moist chlorine. (1 line)

83. What happens when a mixture of chlorine and hydrogen is exposed to bright sunlight?

84. Chlorine water first turns blue litmus and then it. Dry chlorine gas has on dry litmus.

85. Petrol and turpentine both burn in chlorine with a flame, forming black and fumes of

86. Decomposition occurs when a splits up into simpler For example, potassium chlorate decomposes on heating into and oxygen. Chlorine water decomposes in sunlight to form the gas and acid.

87. When two or more substances combine to form a single substance the reaction is called For example, hydrogen and chlorine combine to form

88. Complete the following chemical statements:—

Chlorine + ... $\rightarrow$ Hypochlorous Acid + ...

Hydrochloric Acid + Manganese Dioxide $\rightarrow$ Manganese Chloride + ...

..... + ...

Copper Sulphate + ... $\rightarrow$ Copper Carbonate + ...

..... + ... $\rightarrow$

Lead Chloride + Sodium Nitrate.

Lead Chloride + ... $\rightarrow$

..... + Hydrochloric Acid.

Slaked Lime + ... $\rightarrow$ Bleaching Power + ...

.....

..... + ... $\rightarrow$

Sodium Hypochlorite + Sodium Chloride + Water.

Silver Nitrate + ... → Silver Chloride
+ Sodium Nitrate.

..... + Barium Chloride →
Barium Sulphate + Hydrochloric Acid.

89. Concentrated sulphuric acid and common salt give off a colourless gas called If an oxidizing agent is also added a coloured gas is formed called

90. 50 c.cm. of distilled water required 1 c.cm. of soap solution to form a good lather. 50 c.cm. of water A required 6 c.cm. of soap solution to form a similar lather. After boiling 50 c.cm. of water A only 1 c.cm. of soap solution was required. What can you deduce about A? Give reasons. (4 lines)

91. If water A had required only 3 c.cm. of soap solution to form a lather after boiling, what could you deduce about it? Give reasons. (4 lines)

CHAPTER VII

GENERAL PROPERTIES OF SOLIDS, LIQUIDS, AND GASES

To be studied at the same time as Chapter IV of
General Science for Tropical Schools, Book II.

§6. The pressure on a surface is the force (or thrust) on unit area of the surface.

$$\text{Pressure} = \frac{\text{Force or Thrust}}{\text{Area}}$$

$$\text{Force or Thrust} = \text{Pressure} \times \text{Area}.$$

Force is usually measured in grams or in pounds, and pressure in gm. per sq. cm. or in lb. per sq. in. or in lb. per sq. ft.

Therefore,

$$\text{Force in lb.} = \text{Pressure in lb. per sq. in.} \times \text{Area in sq. in.}$$

$$\text{Force in gm.} = \text{Pressure in gm. per sq. cm.} \times \text{Area in sq. cm.}$$

The pressure on fluids (liquids and gases) may also be stated in (i) atmospheres

and (ii) height of mercury or water column. Thus the normal pressure of the atmosphere may be stated as:—

- (a) 1 atmosphere.
- (b) 14.7 lb. per sq. in.
- (c) 1,034 gm. per sq. cm.
- (d) 76 cm. or 30 in. of mercury.
- (e) 34 ft. of water.

If the pressure is 76 cm. of mercury or 34 ft. of water it means that the pressure will support or balance a column of mercury 76 cm. high or a column of water 34 ft. high.

The mercury column in a mercury barometer falls one inch for every rise of 900 ft. in altitude.

Fluids transmit pressure equally in all directions, i.e. the pressure at any point in a liquid or gas is the same in all directions.

The pressure on a surface under a liquid at rest is equal to the vertical height of the column of liquid multiplied by the density of the liquid. Thus

$$\begin{aligned} \text{Pressure of a liquid} &= \text{Height} \times \text{Density} \\ \text{Pressure in lb. per sq. ft.} &= \text{Height in ft.} \times \text{Density in lb. per c.ft.} \\ \text{Pressure in gm. per sq. cm.} &= \text{Height in cm.} \times \text{Density in gm. per c.cm.} \end{aligned}$$

WORKED EXAMPLES ON PRESSURE IN FLUIDS

(Note: In all the examples and problems in this chapter the density of mercury is taken as 13.6 gm. per c.cm. and the density of water as 62.5 lb. per c.ft. unless otherwise stated.)

Example 30. The pressure of the atmosphere is 30 in. of mercury. Calculate the pressure in lb. per sq. in.

$$\begin{aligned} \text{Atmospheric pressure} &= \text{Pressure of a mercury column 30 in. high} \\ &= \text{Height of column} \times \text{Density of mercury} \\ &= 30 \text{ in.} \times 13.6 \text{ gm. per c.cm.} \\ &= 2\frac{1}{2} \text{ ft.} \times 13.6 \times 62.5 \text{ lb. per c.ft.} \\ &= \frac{2\frac{1}{2} \text{ ft.} \times 13.6 \times 62.5}{12 \times 12} \text{ lb. per sq. in.} \\ &= 14.76 \text{ lb. per sq. in.} \end{aligned}$$

Example 31. The atmospheric pressure is 1,034 gm. per sq. cm. Express this in cm. of mercury.

The pressure of a column of mercury is given by the height of the column multiplied by the density.

Therefore,

$$\text{Height in cm.} \times \text{Density in gm. per c.cm.} = 1,034 \text{ gm. per sq. cm.}$$

$$\text{Height} \times 13.6 = 1,034$$

$$\text{Height} = \frac{1,034}{13.6} \text{ cm.}$$

$$= 76 \text{ cm. approx.}$$

Example 32. What is the water pressure and also the total pressure on a submarine 50 ft. below the surface in sea-water (density 64 lb. per c.ft.)? Atmospheric pressure is 34 ft. of water.

The pressure of the sea-water on the submarine

$$= \text{Depth of sea-water} \times \text{Density}$$

$$= 50 \text{ ft.} \times 64 \text{ lb. per c.ft.}$$

$$= 3,200 \text{ lb. per sq. ft.}$$

The total pressure on the submarine is equal to the water pressure plus the atmospheric pressure.

$$\text{Atmospheric pressure} = 34 \text{ ft. of water}$$

$$= 34 \text{ ft.} \times 62.5 \text{ lb. per c.ft.}$$

$$= 2,125 \text{ lb. per sq. ft.}$$

Therefore,

$$\text{Total pressure} = 3,200 + 2,125 \text{ lb. per sq. ft.}$$

$$= 5,325 \text{ lb. per sq. ft.}$$

Example 33. The bottom of a tank measures 2 metres by 1 metre. The tank contains water to a depth of 10 cm. What is the total force of the water on the bottom of the tank?

$$\text{Pressure due to the water} = \text{Height of water} \times \text{Density}$$

$$= 10 \text{ cm.} \times 1 \text{ gm. per c.cm.}$$

$$= 10 \text{ gm. per sq. cm.}$$

$$\text{Area of bottom of tank} = 2 \text{ metres} \times 1 \text{ metre}$$

$$= 200 \times 100 \text{ sq. cm.}$$

$$\text{Force due to the water} = \text{Pressure} \times \text{Area}$$

$$= 200 \times 100 \times 10 \text{ gm.}$$

$$= 200,000 \text{ gm.} = 200 \text{ kg.}$$

Example 34. A rectangular block of wood is 5 cm. by 2 cm. in cross-section. It floats in water to a depth of 10 cm. What is the upward force of the water on the bottom of the block?

$$\begin{aligned}\text{Pressure of the water at a depth of 10 cm.} &= \text{Depth} \times \text{Density} \\ &= 10 \text{ cm.} \times 1 \text{ gm. per c.cm.} \\ &= 10 \text{ gm. per sq. cm.}\end{aligned}$$

This pressure acts in all directions, and therefore exerts an upward force on the bottom of the block.

$$\begin{aligned}\text{Upward force} &= \text{Pressure} \times \text{Area of block} \\ &= 10 \times 5 \times 2 \text{ gm.} \\ &= 100 \text{ gm.}\end{aligned}$$

PROBLEMS ON FLUID PRESSURE

[Density of mercury 13.6 gm. per c.cm., of water 62.5 lb. per c.ft.]

53. If the height of the mercury barometer is 30 in. and of the water barometer 34 ft. calculate the specific gravity of mercury.

54. A pressure is 9.84 lb. per sq. in. Express this in inches of mercury.

55. A mercury barometer reads 75 cm. What would be the height (a) of a water barometer, (b) of a glycerine barometer (specific gravity of glycerine 1.3) if the pressure remains the same?

56. A barometer reads 30 in. at sea-level and 27 in. at the top of a hill. What is the approximate height of the hill?

57. There is a difference of 1 in. between the height of a mercury barometer at sea-level and at an altitude of 900 ft. Find the difference between the heights of a water barometer at sea-level and at 900 ft. Also, calculate the difference in cm. between the heights of a mercury barometer at sea-level and at an altitude of 250 metres.

58. Calculate the total pressure in lb. per sq. in. on a submarine at a depth of 68 ft. in water. (Atmospheric pressure is equal to 34 ft. of water.)

59. A vertical tube $36\frac{1}{2}$ ft. long contains $2\frac{1}{2}$ ft. of mercury and the rest of the tube contains water. What is the pressure in atmospheres at the bottom of the tube due to the two liquids?

60. What is the approximate reading of a mercury barometer at a height of (a) 3,600 ft., (b) 1,200 ft. and (c) 500 metres?

61. The pressure at the bottom of a tank full of petrol is 1,050 gm. per sq. cm. Calculate the height of the tank (neglecting atmospheric pressure in your calculation). The specific gravity of petrol is 0.7.

62. The mercury in a mercury barometer falls 1 in. for an increase in altitude of 900 ft. Prove that these figures show that the atmosphere, if it was of uniform density, would extend for 5 miles only above the surface of the earth.

63. The pressure of a laboratory gas supply is read on an open-tube water manometer as 6 in. What is the total pressure exerted by the gas in lb. per sq. in. if the atmospheric pressure is 14.7 lb. per sq. in.?

64. The total pressure of the water supply in a house is 4 atmospheres. If the house is 250 feet above sea-level at what altitude is the reservoir? (Atmospheric pressure is equal to 34 ft. of water.)

BOYLE'S LAW

[Not required for General Science, taken as a Single Subject]

§7. **Boyle's Law** states that the volume of a given quantity of gas varies inversely as the pressure upon it, if the temperature is constant.

Thus,

Pressure is proportional to $\frac{1}{\text{volume}}$ (at constant temperature)

i.e. Pressure $\times$ Volume = a constant (,, ,, ,,)
or PV = a constant (,, ,, ,,)

If the pressure on a given quantity of gas is changed then

First pressure $\times$ First volume = Second pressure $\times$ Second volume
or $P_1V_1 = P_2V_2$ (when temperature is constant)

WORKED EXAMPLES ON BOYLE'S LAW

Example 35. A given quantity of air has a volume of 120 c.cm. at a pressure of 75 cm. What is its volume at 80 cm. pressure?

First pressure $\times$ First volume = Second pressure $\times$ Second volume (by Boyle's Law)

i.e. $75 \text{ cm.} \times 120 \text{ c.cm.} = 80 \text{ cm.} \times \text{Second volume}$

$$\begin{aligned}\text{Second volume} &= \frac{75 \times 120}{80} \text{ c.cm.} \\ &= 112.5 \text{ c.cm.}\end{aligned}$$

Example 36. The volume of the gas in a balloon at 30 in. mercury pressure is 2.5 c.ft. The balloon rises to a certain height and the volume of the gas at the same temperature is now 3.0 c.ft. What is the pressure at this altitude, and what is the approximate altitude?

First pressure $\times$ First volume = Second pressure $\times$ Second volume (by Boyle's Law)

i.e. $30 \text{ in.} \times 2.5 \text{ c.ft.} = \text{Second pressure} \times 3.0 \text{ c.ft.}$

$$\begin{aligned}\text{Second pressure} &= \frac{2.5 \times 30}{3} \text{ in.} \\ &= 25 \text{ in. mercury.}\end{aligned}$$

The pressure at the given altitude is 25 in. mercury.

The pressure on the balloon has decreased from 30 to 25 in., i.e. 5 in. The barometric pressure, however, falls 1 in. mercury for every rise of 900 ft. Therefore the altitude is $5 \times 900 \text{ ft.} = 4,500 \text{ ft.}$ approximately.

Example 37. A gas jar is 20 cm. long and of uniform cross-section. The jar is lowered, mouth downwards, into a tank of water until the water rises 5 cm. in the gas jar. What is the depth of the jar if the barometric pressure is 34 ft. of water?

Since the cross-section of the jar is uniform the volume of air in the jar is proportional to the length of the jar filled with air. The first length of air in the jar is 20 cm. and the second length is 20 cm. minus the height of water in the jar, i.e. $20 - 5 = 15 \text{ cm.}$

First volume $\times$ First pressure = Second volume $\times$ Second pressure (by Boyle's Law)

i.e. $20 \text{ units} \times 34 \text{ ft.} = 15 \text{ units} \times \text{Second pressure}$

$$\begin{aligned}\text{Second pressure} &= \frac{20 \times 34}{15} \text{ ft. water} \\ &= 45.33 \text{ ft. water.}\end{aligned}$$

34 ft. of this pressure is due to the atmosphere. Therefore $45.33 - 34$, i.e. 11.33 ft. of the pressure, is due to the water in the tank.

Depth of jar in the tank is 11.33 ft.

Example 38. Oxygen is collected in a test-tube over mercury. The volume of the oxygen is 10 c.cm. when the height of the mercury in the test-tube is 3 in. greater than the mercury level outside the tube. What is the volume of oxygen at atmospheric pressure (30 in. mercury)?

$$\begin{aligned}\text{Atmospheric pressure} &= \text{Pressure of oxygen} + 3 \text{ in. mercury} \\ 30 \text{ in.} &= \text{Pressure of oxygen} + 3 \text{ in.}\end{aligned}$$

i.e. first pressure of oxygen is $30 - 3$ in., i.e. 27 in. mercury.

Using Boyle's Law, $P_1V_1 = P_2V_2$ (when the temperature is constant)

$$27 \text{ in.} \times 10 \text{ c.cm.} = 30 \text{ in.} \times V_2$$

$$\begin{aligned}V_2 &= \frac{27 \times 10}{30} \text{ c.cm.} \\ &= 9 \text{ c.cm.}\end{aligned}$$

Volume of oxygen at atmospheric pressure is 9 c.cm.

Example 39. The cylinder of an exhaust pump has a volume of 250 c.cm. The pump is used to exhaust a bell-jar of volume 1,000 c.cm. containing air at 75 cm. pressure. What is the pressure in the jar after (a) one stroke, (b) two strokes of the piston?

During the first stroke the 1,000 c.cm. of air in the bell-jar expands to fill the bell-jar and cylinder of the pump, i.e. the volume of air becomes

$$1,000 \text{ plus } 250 \text{ c.cm.} = 1,250 \text{ c.cm.}$$

Using Boyle's Law, $P_1V_1 = P_2V_2$ (when the temperature is constant)

$$75 \text{ cm.} \times 1,000 \text{ c.cm.} = P_2 \times 1,250 \text{ c.cm.}$$

$$\begin{aligned}P_2 &= \frac{75 \times 1,000}{1,250} \text{ cm.} \\ &= 60 \text{ cm. mercury.}\end{aligned}$$

Pressure in the jar after one stroke is 60 cm. mercury.

At the beginning of the second stroke there are 1,000 c.cm. of air in the bell-jar at a pressure of 60 cm. At the end of the second stroke the air has become 1,250 c.cm. Using Boyle's Law again,

$$\begin{aligned}60 \text{ cm.} \times 1,000 &= P_2 \times 1,250 \\ P_2 &= 48 \text{ cm.}\end{aligned}$$

Pressure in the jar after two strokes is 48 cm. mercury.

Example 40. A mercury barometer contains a little air above the mercury and therefore gives incorrect readings. The barometer reads 29 in. and the space

above the mercury is 6 in. long. The barometer tube is lowered into a bowl of mercury. The barometer now reads 28 in. and the space above the mercury is 3 in. long. What is the true barometric pressure?

Let the true barometric pressure be P cm. mercury.

When the barometer reads 29 in. the pressure of the air is therefore $P - 29$ in.
When the barometer reads 28 in. the pressure of the air is $P - 28$ in.

The volume of the air is proportional to the length of the air column (assuming that the barometer tube is uniform).

Using Boyle's Law,

$$P_1 V_1 = P_2 V_2 \text{ (when the temperature is constant)}$$

$$(P - 29) \text{ in.} \times 6 \text{ units} = (P - 28) \text{ in.} \times 3 \text{ units}$$

$$\text{i.e.} \quad 6P - 174 = 3P - 84$$

$$3P = 90 \text{ in.}$$

$$P = 30 \text{ in.}$$

True barometric pressure is 30 in. mercury.

PROBLEMS ON BOYLE'S LAW

[Atmospheric pressure is 76 cm. mercury or 34 ft. water]

65. Calculate the values of the missing pressures and volumes in the following table:—

<i>First pressure</i>	<i>First volume</i>	<i>Second pressure</i>	<i>Second volume</i>
(a) 75 cm. mercury	100 c.cm.	100 cm. mercury	
(b) 30 in. mercury	2 c.ft.		3 c.ft.
(c) 4 atmospheres		5 atmospheres	16 c.metres
(d) 34 ft. water	70 c.cm.		105 c.cm.
(e) 14 lb. per sq. in.		21 lb. per sq. in.	60 c.in.
(f)	4V units	900 gm. per sq. cm.	5V units

66. A balloon is filled at sea-level and rises until it becomes twice its original volume. What is the pressure at this altitude?

67. A balloon is tied to a stone and dropped into a lake. What is the pressure in atmospheres when the size of the balloon becomes one-half of its size at the surface of the lake? What is the depth of the balloon below the surface of the lake when it becomes one-third of its original size?

68. A uniform test-tube was lowered into sea-water (specific gravity 1.1) until the volume of air in the tube was halved. What was the depth to which it was lowered?

69. A gas jar is lowered 68 ft. below the surface of fresh water. What is the total pressure on the air in the jar? What fraction of the jar is now filled with water if the jar was originally full of air?

70. A swimmer breathes out 10 c.in. of air when at a depth of 8 ft. 6 in. in a swimming pool. What is the volume of this air when it reaches the surface?

71. A tin can is 6 in. high and of radius 1 in. All the air is pumped out of the can. Find the force tending to crush the can when the atmospheric pressure is 15 lb. per sq. in.

72. If $\frac{22}{7}$ c.in. of air at atmospheric pressure now leaks into the tin can described in problem No. 71, what is the pressure inside the can (a) in atmospheres, (b) in lb. per sq. in.? Find the force now tending to crush the can.

73. The pressure of the air inside certain motor-car tyres should be 25 lb. per sq. in. The internal volume of the tyres is 600 c.in. What volume of air at atmospheric pressure (15 lb. per sq. in.) is required to fill these tyres?

74. A barometer tube is 40 in. long and contains a little air above the mercury. The barometer reads 28 in. when the true pressure is 30 in. What is the true pressure when the barometer reads 24 in.?

75. The hole in the end of a bicycle pump is closed by a screw. The inside diameter of the pump is 1 in. What total force must be used to push in the handle of the pump until the volume of the air inside the pump is one-quarter its original volume at atmospheric pressure, which is 14.7 lb. per sq. in.?

BALANCING COLUMNS OF LIQUIDS

§8.

Consider a column of water AB in one limb of a U-tube balancing a column of liquid CD in the other limb. The water and the liquid are separated by mercury if the liquid mixes with water (Fig. 1); the mercury is not necessary if the water

and the liquid do not mix (Fig. 2). In Fig. 1 the columns of mercury up to levels A and C are equal and therefore balance. In Fig. 2 the columns of water up to

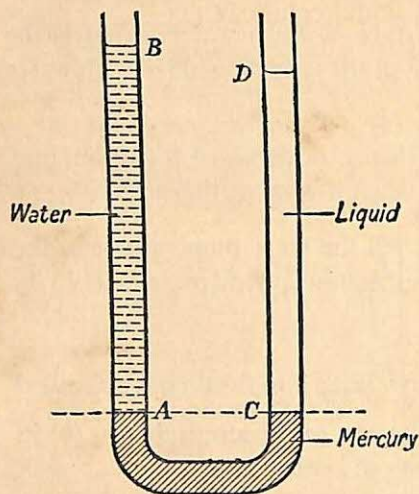


FIG. 1

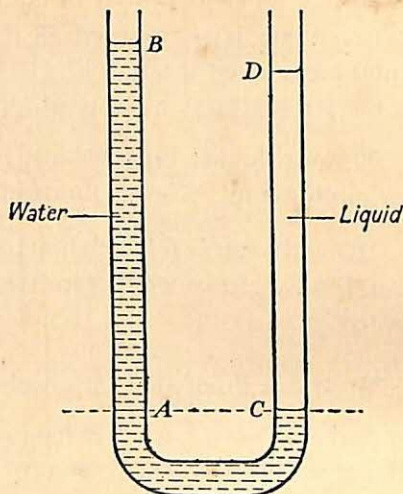


FIG. 2

BALANCING COLUMNS OF LIQUIDS

levels A and C are equal and therefore balance. Also, the atmospheric pressure on both sides of the U-tube is equal and may be neglected. Therefore,

Pressure of water column AB = Pressure of liquid column CD

i.e.

$$\text{Height AB} \times \text{Density of water} = \text{Height CD} \times \text{Density of liquid}$$

i.e.

$$\frac{\text{Density of liquid}}{\text{Density of water}} = \frac{\text{Height of water column AB}}{\text{Height of liquid column CD}}$$

or

$$\text{Specific gravity of liquid} = \frac{\text{Height of water column AB}}{\text{Height of liquid column CD}}$$

Remember: AB and CD are *vertical* heights of the columns. The diameters of the limbs of the U-tube make no difference to the heights of the columns of liquids which balance each other.

§9. Hare's apparatus consists of an inverted U-tube arranged as shown in Fig. 3.

The pressure at B and at D is the same. Also the pressure at A and at C is one atmosphere. Therefore, it can be shown that

$$\frac{\text{Density of liquid}}{\text{Density of water}} = \frac{\text{Height of water column AB}}{\text{Height of liquid column CD}}$$

or

$$\text{Specific gravity of liquid} = \frac{\text{Height of water column AB}}{\text{Height of liquid column CD}}$$

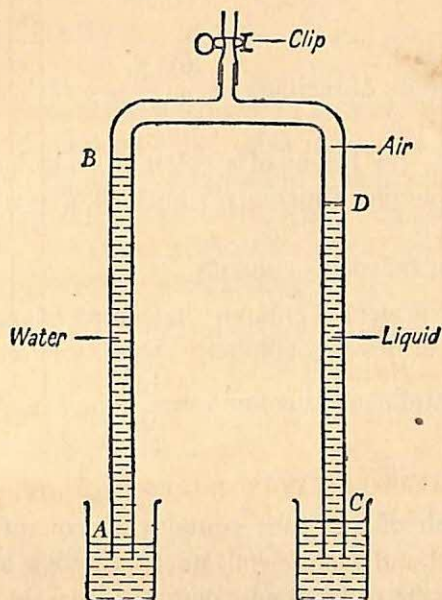


FIG. 3. HARE'S APPARATUS

Of course in the experiments shown in Figs. 1, 2, and 3 it is not necessary for one of the liquids to be water, and in general it can be said that when two columns of liquids are balancing, then

$$\frac{\text{Density of Liquid X}}{\text{Density of Liquid Y}} = \frac{\text{Height of Liquid Y}}{\text{Height of Liquid X}}$$

WORKED EXAMPLES ON BALANCING COLUMNS

Example 41. A column of water 40 cm. high balances either a column of alcohol 50 cm. high or a column of mercury 3 cm. high. Calculate the specific gravities of these two liquids.

Using the principle of balancing columns, we have

$$\begin{aligned}\text{Specific gravity of alcohol} &= \frac{\text{Height of water column}}{\text{Height of alcohol column}} \\ &= \frac{40 \text{ cm.}}{50 \text{ cm.}} = 0.8\end{aligned}$$

Similarly,

$$\text{Specific gravity of mercury} = \frac{40 \text{ cm.}}{3 \text{ cm.}} = 13.3.$$

Example 42. Calculate the height of a column of alcohol (specific gravity 0.8) which will balance a column of mercury 5 in. high. (Specific gravity of mercury is 13.6.)

Using the principle of balancing columns,

$$\begin{aligned}\frac{\text{Height of alcohol column}}{\text{Height of mercury column}} &= \frac{\text{Density of mercury}}{\text{Density of alcohol}} \\ \text{i.e. Height of alcohol column} &= \frac{13.6}{0.8} \times 5 \text{ in.} \\ &= 85 \text{ in.}\end{aligned}$$

Example 43. One limb of a U-tube contains 30 cm. of water and 6 cm. of mercury. The other limb contains 25 cm. of salt solution and 6 cm. of mercury. Calculate the specific gravity of the salt solution.

The columns of the mercury are of equal length (6 in.) and therefore balance. Hence, by the principle of balancing columns,

$$\begin{aligned}\text{Specific gravity of salt solution} &= \frac{\text{Height of water column}}{\text{Height of salt solution column}} \\ &= \frac{30}{25} \text{ cm.} = 1.2.\end{aligned}$$

Example 44. Columns of water and of copper sulphate solution are in a U-tube and are separated by mercury. The mercury column is 1 cm. higher on the copper sulphate side than on the water side. If the water column is 37.6 cm. high and the copper sulphate 20 cm. high calculate the density of the copper sulphate solution.

37.6 cm. of water are balanced by 1 cm. of mercury and 20 cm. of copper sulphate solution. By the principle of balancing columns,

$$\text{Height of water column} \times \text{Density} = (\text{Height of mercury column} \times \text{Density}) + (\text{Height of copper sulphate solution} \times \text{Density})$$

i.e. $37.6 \times 1 = (1 \times 13.6) + (20 \times \text{Density of copper sulphate solution})$

i.e. $\text{Density of copper sulphate solution} = \frac{37.6 - 13.6}{20} \text{ gm. per c.cm.}$

$$= \frac{24}{20} = 1.2 \text{ gm. per c.cm.}$$

Example 45. A U-tube contains a column of mercury. Water is poured into one side of the U-tube and brine into the other side until the length of the brine column is 25.2 cm. and the tops of the water and the brine columns are at the same level. It is now found that the mercury is 0.2 cm. higher in the water limb than in the brine limb. Find the density of the brine.

(The student should first draw a clear diagram.)

The length of the water column is

$$25.2 - 0.2 = 25 \text{ cm.}$$

Therefore 25 cm. water and 0.2 cm. mercury balance 25.2 cm. brine. Using the principle of balancing columns,

$$(\text{Height of water column} \times \text{Density}) + (\text{Height of mercury column} \times \text{Density}) = \text{Height of brine} \times \text{Density}$$

i.e. $(25 \times 1) + (0.2 \times 13.6) = 25.2 \times \text{density of brine}$

i.e. $\text{Density of brine} = \frac{25 + 2.72}{25.2} \text{ gm. per c.cm.}$

$$= \frac{27.72}{25.2} = 1.1 \text{ gm. per c.cm.}$$

PROBLEMS ON BALANCING COLUMNS

76. A column of water 50 cm. long can balance a column of alcohol 62.5 cm. long or a column of glycerine 40 cm. long, all these heights being measured vertically. Calculate the specific gravities of the liquids.

77. Calculate the height of a column of glycerine (specific gravity 1.3) which will balance a column of alcohol (specific gravity 0.8) of height 20 cm.

78. Using Hare's apparatus it is found that a column of brine 25 cm. high balances a column of copper sulphate solution 24 cm. high. Which solution has the greater density, and how many times is it greater?

79. Water was balanced against acid in Hare's apparatus. All the distances were measured from the top of the bench and the following results were obtained: water in the beaker 6 cm.; water in the tube 36 cm.; acid in the beaker 5.5 cm.; acid in the tube 28 cm. Find the specific gravity of the acid.

80. Paraffin oil (specific gravity 0.8) is poured into one limb of a U-tube containing water. The water in the other limb rises 4 cm. Prove that the length of the oil column is 10 cm.

81. (a) Hare's apparatus is used to find the specific gravity of ammonia solution. The water column in one limb is 12 in. high and the ammonia solution is 12.5 cm. What is the density of the ammonia solution, and what is the pressure of the air above the water and the ammonia solution in the apparatus (when the atmospheric pressure is 34 ft. of water)?

(b) A U-tube contains water. Oil of specific gravity 0.8 is poured into one of the limbs until the length of the oil column is 7.5 cm. Prove that the water level in the other limb rises 3 cm.

GENERAL PROPERTIES OF SOLIDS, LIQUIDS, AND GASES

(continued)

EXERCISE 5. To be completed after studying Chapter IV of *General Science for Tropical Schools, Book II.*

1. A barometer is used to measure
Mercury is used in a simple barometer because it has a high
The normal height of the mercury column in a mercury barometer at sea-level is about cm. or in.

2. If an aneroid barometer is carried up a mountain the reading
..... approximately 1 in. for every rise of 900 ft.

3. Does the air in a room press outwards against the walls?

4. An aneroid barometer used in aeroplanes for measuring altitude is called

5. Three barometers at the same place read 28, 29, and 30 in. respectively Which one of the three readings is more likely to be correct?
Why?.....
6. Normal atmospheric pressure is about pounds per square inch.
7. A siphon uses the two forces and
8. What is inside the thin metal box of an aneroid barometer?.....
9. Why is a tall reservoir dam thicker at the bottom than at the top? (1 line)
10. Give two reasons why a water barometer is rarely used. (2 lines)
11. If the mercury column is 30 in. high in a tube of 1 sq. cm. cross-section, what will be the height in a barometer tube of 2 sq. cm. cross-section?
12. Hollow metal hemispheres used to demonstrate air pressure are called hemispheres.
13. Name three appliances which depend on air pressure for their working.
14. State two properties of air which make it suitable for use in car and bicycle tyres.
15. A lift-pump cannot raise water more than ft. even if it is mechanically perfect.
16. When the piston of a lift-pump is raised the foot-valve is and the piston valve is
17. When the piston of a force-pump is pushed downwards the foot-valve is and the delivery valve is
18. Why does a balloon stop rising when it reaches a certain height? (2 lines)
19. Mention three examples of the use of hydraulic presses. (2 lines)

ADDITIONAL EXERCISES

[Not required for General Science, taken as a Single Subject]

1. The mixing of gases or liquids when not caused by gravity or stirring or shaking is called
2. All substances are made up of very small particles called which are always in motion. As the millions of of a gas strike the walls of a vessel they exert a
3. The force of attraction between like particles is called and that between particles of different kind is called
4. If a liquid wets the surface of a containing vessel, which is the greater force, cohesion or adhesion?
5. Give three examples of capillarity in everyday life. (2 lines)
6. Are the molecules of a gas packed close together or is there much space between them?
7. If the pressure on a gas is increased its becomes less.
8. Why is it easier to write in ink on glazed paper than on unglazed paper (e.g. blotting-paper)? (2 lines)
9. When carbon dioxide and hydrogen have been mixed in a closed jar all the heavier carbon dioxide will not settle to the bottom. Explain this. (3 lines)
10. Ink will 'climb up' blotting-paper. Explain this. (2 lines)
11. Steel is much denser than water, but a razor-blade will float if placed gently on a water surface. Explain this. (2 lines)
12. Why does a balloon filled with hydrogen rise in air only to a certain height and no farther? (2 lines)
13. State Boyle's Law. (3 lines)
14. Explain why the phrase 'as long as the temperature remains the same' is necessary in the statement of Boyle's Law. (2 lines)
15. A balloon which is going to rise several miles is only partly inflated before being released. Explain this. (2 lines)

CHAPTER VIII

PLANT LIFE. THE SOIL

EXERCISE 6. To be completed after studying Chapters V and VI of *General Science for Tropical Schools, Book II.*

1. What colour is produced when starch and iodine react?
2. What is the essential function of green leaves?
.....
3. What three external conditions increase the rate at which green leaves lose water vapour?
4. The loss of water vapour by leaves is called
The water is lost through tiny openings called.....
5. The substance in a leaf which makes photo-synthesis possible is
..... The energy for the process comes from
6. The green colouring matter in a leaf (i.e. leaf-green) is called
7. Starch and sugar contain the three elements
..... and are classified as
8. During respiration in plants, the leaves use
..... from the air and give off and
into the air. The process is carried on during
9. Transpiration, respiration, osmosis, photo-synthesis, fertilization are five processes. Which of these are associated with (i) the movement of water in a plant? (ii) the making of food in a plant?
.....
10. How do plants obtain the gas they require for respiration? (2 lines)
11. Explain why some plants wilt quickly when exposed to a strong wind.
(2 lines)
12. State the three conditions necessary for photo-synthesis. (2 lines)
13. How would you test for starch in a green leaf? (3 lines)

14. State four ways in which water is important to plants. (3 lines)
15. State three ways in which a living plant differs from non-living material.
.....
16. What is the name given to the complete set of sepals?
What is the name given to the complete set of petals?
17. Inside the corolla of a flower are many each with
a head containing yellow particles called
18. What two processes in the reproduction of flowering plants may be helped
by wind?.....
19. Plants take in water through the by a
process called The concentration of
salts in the soil water is than the concentration of these
salts in the of the plant.
20. Name four solid constituents of soil.
21. Name two non-solid constituents of soil necessary for the healthy growth of
plants.....
22. The same amount of water is poured through equal volumes of dry sand
and dry clay. The water soaks faster through the while the
..... retains more water.
23. Water rises by capillarity more in sand than in
clay, but finally it rises to the greater height in the
24. Name seven elements needed for healthy plant growth which plants
normally obtain from soil..... Which three of these elements are
often present in insufficient amounts?.....
25. Clay holds water of adhesion than does sand.
26. State two ways in which cultivation helps to improve the fertility of soil.
.....
27. Two kinds of organic manure which improve soil fertility are
..... and

28. Name two artificial fertilizers which contain nitrogen.
29. What is humus?
30. Why is humus important to plants? (2 lines)
31. Why is the top layer of soil usually darker in colour than the layer below?
32. Mention four ways in which earthworms increase soil fertility. (2 lines)
33. Give three ways in which animals help to scatter fruits or seeds away from the parent plant. (3 lines)
34. Where is starch found in a green leaf?.....
35. When starch or sugar is heated a mass of black is formed.
36. Describe three common features of fruits or seeds which are dispersed by wind. (2 lines)
37. In pollination from a flower is put on the
38. In self-pollination, the and the both belong to the same flower. In cross-pollination, the from one flower reaches the of another flower.
39. State briefly four ways in which flowers secure cross-pollination. (3 lines)
40. What two processes must precede the formation of a seed? and
41. What is a water culture solution? (3 lines)
42. Name three essential elements in a water culture solution. (1 line)
43. Outline any crop rotation with which you are familiar. (3 lines)
44. How does the stickiness of the stigma help fertilization? (1 line)
45. How may a piece of stem be distinguished from any other part of a plant?
46. Describe how insects help in pollination. (2 lines)

47. Mention four main ways in which fruits and seeds are scattered. (2 lines)
48. A seed is a ripened and a fruit is a ripened
49. Insects are attracted to flowers by and by
50. How would you detect the presence of a carbonate in soil? (2 lines)
51. How would you find out if soil contains humus? (2 lines)
52. State briefly what is meant by the weathering of rocks? (3 lines)
53. State briefly four ways in which the weathering of rocks is brought about. (2 lines)
54. State two ways in which the decay of dead leaves improves the fertility of the soil.
55. Decay of plants and animals is brought about by and by
56. What are two natural sources of supply of nitrogen (as nitrates) to the soil?
57. The pollen grain germinates to produce a tube which grows down the and into the
58. Leguminous plants are always included in crop rotations because
59. State three methods used to make a heavy (clay) soil more suitable for growing crops. (3 lines)
60. If you wished to grow cover-plants on a bare hill-side to prevent soil-wash, what type of root-system would be most suitable?
61. Mention two ways in which soil-erosion ruins land for agriculture. (2 lines)
62. Name the worst weed in your neighbourhood.
63. What kind of soil holds most water?
64. What are lenticels and what is their function? (2 lines)
65. What is 'stem-ringing' and how is it done? (3 lines)
66. Mention two functions of leaf-veins. (2 lines)

67. What kind of plants have stomates in their upper leaf surface only?.....
 What is the advantage of this arrangement?

68. Mention four adaptations that enable plants to present a maximum amount of a leaf-surface to the light. (2 lines)
69. When a tree or shrub is transplanted, some leaves are usually cut off. Give a reason for this

CHAPTER IX

SOUND

To be studied at the same time as Chapter VII of *General Science for Tropical Schools, Book II.*

§10. The *frequency* of a note is the number of vibrations per second. Thus, the 'middle C' note of a piano vibrates 256 times per second, and its time of vibration is $\frac{1}{256}$ second.

When the frequency of one note is double that of a second note then the first note is said to be one *octave* higher than the second note. Thus, 'middle C' has a frequency of 256 vibrations per second. 'Upper C' (one octave higher) has a frequency of 2×256 , i.e. 512 vibrations per second.

Sound travels through solids, liquids, and gases. Some speeds of sound are:—

<i>Medium through which sound travels</i>	<i>ft. per sec.</i>	<i>metres per sec.</i>
Dry air at 0° C.	1,085	331
Dry air at 30° C.	1,147	350
Damp tropical air	1,150	351
Hydrogen at 0° C.	4,265	1,301
Water at 20° C.	4,623	1,410
Sea-water at 20° C.	5,050	1,540
Iron	16,400	5,000
Glass	16,400	5,000

Note that the speed of sound in air is about one-fifth of a mile per second or one mile in five seconds. Light travels at the speed of 186,000 miles per second. Owing to the great difference between these two speeds thunder is usually heard some time after the lightning which caused it is seen.

The *pitch* of a note is its position on the musical scale. The greater the frequency of a note the higher is its pitch. Thus, a note of frequency 260 vibrations per second is of higher pitch than a note of frequency 259.

The *frequency of a vibrating string* (and therefore the pitch of the note given by the string) depends on

(a) *the length of the string*. The longer the string the lower the frequency of vibration and the lower the pitch of the note given by the string;

(b) *the tension of the string*. The greater the tension, the greater the frequency and the pitch;

(c) *the weight per unit length of the string*. The thicker the string the lower the frequency and the pitch.

§11.

[Not required for General Science, taken as a Single Subject]

Sound travels in waves called *longitudinal waves*, which consist of alternate waves of compression and rarefaction.

The *wave-length* of a sound is the distance travelled by the sound in the time of one complete vibration of the particles of the vibrating medium; or

the wave-length of sound is the distance between the middle of one compression (or rarefaction) wave to the middle of the next compression (or rarefaction) wave.

Speed of sound = Wave-length $\times$ Frequency.

WORKED EXAMPLES ON SOUND

[Take the velocity of sound in air as 1,150 ft. per sec. unless otherwise stated]

Example 46. A man hears thunder 8 seconds after seeing the lightning. How far away was the lightning?

In 8 sec. sound travels $8 \times 1,150 \text{ ft.} = 9,200 \text{ ft.}$

The lightning was therefore 9,200 ft. away (or approximately $\frac{5}{8} = 1.6 \text{ miles}$)

Example 47. The echo from a cliff was heard 10 sec. after a gun was fired. How far away was the cliff?

In 10 sec. the sound travelled to the cliff, was reflected, and travelled back. In 10 sec. sound travels $10 \times 1,150$ ft., i.e. 11,500 ft. Therefore twice the distance to the cliff is 11,500 ft.

Therefore, the cliff was $\frac{11,500}{2}$, i.e. 5,750 ft. away.

Example 48. A gramophone turntable is adjusted to make 100 revolutions per minute. The 'middle C' tuning-fork (frequency 256 vibrations per second) makes a wavy line on paper on the turntable. How many complete waves does the fork make in one-quarter of a turn of the table?

100 revolutions are made by the turntable in 1 minute, i.e. 60 sec.

so quarter of a revolution is made in $\frac{60}{100 \times 4}$ sec. = 0.15 sec.

In 1 sec. the tuning-fork makes 256 complete waves, therefore in 0.15 sec. it makes

$$256 \times 0.15 \text{ complete waves} = 38.4$$

i.e. the fork makes 38 complete waves.

Example 49. A cannon and an observer were on each of two hills 13,200 ft. apart. The cannons were fired. One observer found that the time between the flash and sound of the cannon was 11 sec. The other observer found the time was 12 sec. What is the speed of sound in still air?

Let the speed of sound in still air be S feet per sec. and the speed of the wind be w feet per sec.

In one direction the wind helped the sound, and the time was 11 sec. In the opposite direction the wind opposed the sound and the time was 12 sec.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Therefore,

$$S + w = \frac{13,200 \text{ ft.}}{11 \text{ sec.}} = 1,200 \text{ ft. per sec.}$$

$$S - w = \frac{13,200 \text{ ft.}}{12 \text{ sec.}} = 1,100 \text{ ft. per sec.}$$

By addition, $2S$ is 2,300 ft. per sec. and the speed of sound is $\frac{2,300}{2}$, i.e.

1,150 ft. per sec.

Note: It is wrong to take the *average* of the two times and to say that the sound travels 13,200 ft. in still air in $(11 + 12) \div 2$ sec. This method gives an inaccurate answer of 1,148 ft. per sec.

Example 50. A siren made 200 revolutions in 25 sec. and the number of holes in the siren was 48. A tuning-fork had the same pitch as the note given by the siren. What was the frequency of the fork?

Frequency of the note given by the siren = number of holes $\times$ number of revolutions per sec.

$$= 48 \times \frac{200}{25} = 384.$$

Therefore, frequency of the fork is *384 vibrations per sec.*

PROBLEMS ON SOUND

[Take the speed of sound in air as 1,150 ft. per sec. and in water as 5,000 ft. per sec. unless otherwise stated]

82. Lightning flashes 8,050 ft. away from a man. What is the time between the lightning flash being seen and the thunder being heard by the man?

83. A person sees a flash of lightning and hears the thunder 11 sec. later. If sound travels one-fifth of a mile per sec., how far away was the lightning?

84. A high wall 55 ft. from a boy gave an echo one-tenth of a second after the original sound. How far was the boy from the wall when the time between sound and echo was one-fifth of a second, and what was the speed of the sound?

85. A gun was fired from an aeroplane. The echo from the ground was heard 2 sec. after the gun was fired. What was the altitude of the aeroplane?

86. Two hills are 33,500 metres apart. A cannon is fired on one hill and the sound is helped by a wind of 500 cm. per sec. If the speed of sound is 330 metres per sec. what time is taken for the sound of the cannon to reach the second hill? What time would be taken if the wind was opposing the sound?

87. Two boats were on a lake at a distance of 13.5 kilometres apart. A bell was hung in the water from one boat. The bell was struck at the same time as a gun was fired from the boat. The flash of the gun reached an observer in the second boat 9 sec. before the sound travelling through the water. What was the speed of sound in the water?

88. A siren makes 8 revolutions per second. What is the note given if the number of holes is 48? A second siren has 64 holes. How many revolutions per second must it make in order to produce the octave of the first note?

89. A gun was fired by a man standing between two parallel walls. One echo was heard after 1 sec. and the other after $1\frac{1}{2}$ sec. Calculate the distance between the walls.

90. If the velocity of sound in air is 1,100 ft. per sec. calculate the wave-length of the 'middle C' note (frequency 256). What is the wave-length of 'upper C' (which is one octave higher than 'middle C')?

91. The wave-length of a certain note in air is $2\frac{1}{2}$ ft. Calculate the frequency of the note. What is the wave-length of this note in water? (Speed of sound in water is 5,060 ft. per sec.)

92. When tuning-fork A was held near a stretched wire which was vibrating, the fork began to vibrate fairly strongly. Tuning-fork B would not vibrate until the wire had either been shortened slightly or made a little tighter. One of the forks had a frequency of 256 and the other of 260. Which fork had a frequency of 256?

93. The disc of a siren having 40 holes rotates 250 times in 42 seconds. What is the frequency of the note given by the siren? If this note is an octave lower than that of a tuning-fork, what is the frequency of the fork?

94. An organ pipe 3 ft. long is sounding a note. What length organ pipe must be used to produce a note two octaves higher?

SOUND (*continued*)

EXERCISE 7. To be completed after studying Chapter VII, *General Science for Tropical Schools, Book II.*

1. How is sound produced? (*2 lines*)
2. The pitch of a note depends on the
3. The pitch of a note given out by a pipe depends mainly upon the.....
..... of the pipe.
4. The three characteristics of a musical note are its.....

5. 'Middle C' on a piano and 'middle C' on a violin differ in
 but have exactly the same
6. The pitch of the note given out by a vibrating string
 if the length of the string is increased and if the
 tension of the string is decreased.
7. The sound given out by a piano string is louder when the vibrations of the
 string are
8. If two tuning forks are in resonance, they have the same
9. Musical notes have a definite but noises have not.
10. Sound travels through the air by
 waves which consist of alternate waves of and

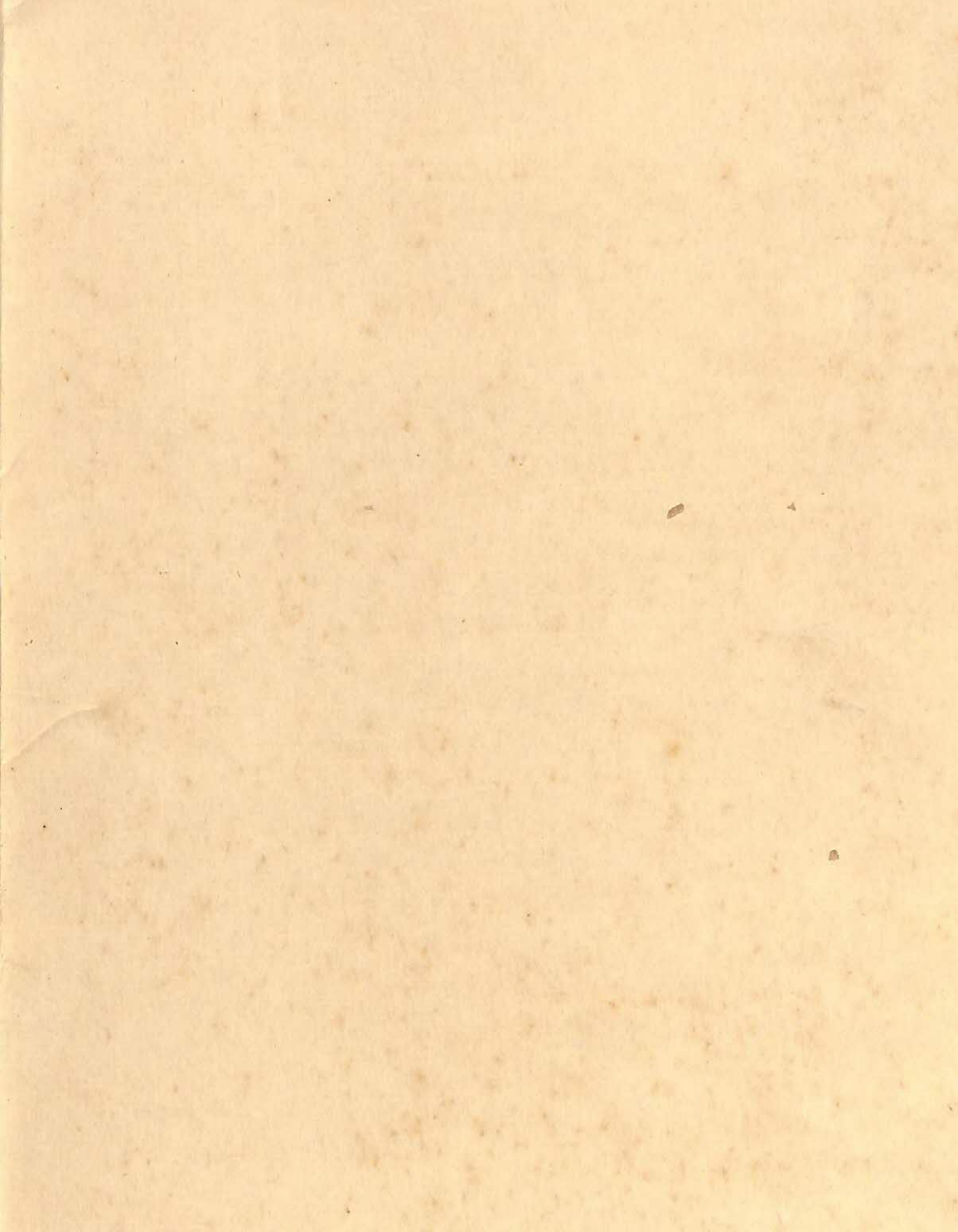
11. What three factors determine the pitch of the note given out by a vibrating
 string? (2 lines)
12. How fast does sound travel through air?
 Through sea-water?
13. Why is a speaker heard more readily inside a room than outside in the
 open air? (2 lines)
14. The strings of a violin producing the high notes are
 and than those producing the low notes.
15. A violinist tunes his violin by altering the of the
 strings.
16. The strings of a piano producing the high notes are,
, and than those producing
 the low notes.
17. When a piano string is flat or below pitch the piano tuner
 it.
18. The faster an object vibrates, the is the pitch of the
 sound which is produced.
19. High notes have wave-lengths than have low
 notes.

20. What part in sound production is played by the body of a violin? (2 lines)
21. An echo shows that sound waves can be
22. Mention two uses to which echoes have been put? (2 lines)
23. The octave of a note has a frequency as much as the frequency of the note itself. Thus the octave of 'middle C' (256 vibrations per second) has a frequency of
24. A node is a point in a sound wave where the motion of the particles is An anti-node is a point where the motion of the particles is

ANSWERS TO NUMERICAL PROBLEMS

1. (a) 0.76 gm. per c.cm.
(b) 1.03 gm. per c.cm.
(c) 0.047 lb. per c.in.
(d) 9 gm. per c.cm.
(e) 500 lb. per c.ft.
2. (a) 870 gm.
(b) 1,292 gm.
(c) 91.2 gm.
(d) 3.86 gm.
(e) 68.75 lb.
(f) 562.5 lb.
3. (a) 7.69 c.cm.
(b) 602 c.cm.
(c) 1,428.6 c.cm.
(d) 73.5 c.cm.
(e) 8.584 litres
(f) 0.736 c.ft.
(g) 0.8 c.ft.
(h) 0.588 c.cm.
4. (a) 100 gm.
(b) 730 gm.
(c) 78 gm.
5. 34 c.cm.
6. 11.2 gm. per c.cm.
7. 1.33 cm.
8. 20.9 lb.
9. 14.76 lb., 1,034 gm.
10. 14.76 lb., 1,034 gm.
11. $y - x$ c.cm.
12. 95.3 cm.
13. 1.1 gm. per c.cm.
14. 12,500 lb.
15. 22,000 kg.
16. 0.01 sq. cm.
17. 7.2
18. A 0.975, B 1.05, C 1.41
19. (a) 360.4 gm.
(b) 46.2 gm.
(c) 37.9 gm.
20. 0.1 cm.
21. 1.2 c.ft.
22. 5,200 gm.
23. 75 lb.
24. 840 kg.
25. 0.00125 gm. per c.cm.
26. 79.81 gm.
27. 3.75 gm.
29. 0.95 gm. per c.cm.
30. 7.55 gm. per c.cm.
31. 4 c.cm., 5 gm. per c.cm.
32. 5 gm.
33. 88.24 gm.
34. 21 gm., 21.8 gm.
35. 0.8 gm. per c.cm., 62 gm.
36. 1,833.33 lb.
37. 1.2 gm. per c.cm.
40. 5 c.cm.
41. 20 c.cm.
42. 0.67 gm. per c.cm., 36 c.cm.
43. 0.533 gm. per c.cm., 46.9 c.cm.
44. 0.67 gm. per c.cm., 7.5 cm.
45. 0.75 gm. per c.cm., 0.9375
46. (a) 16 c.ft.
(b) 15.24 c.ft.
47. 352 gm., 16π gm. or 50.29 gm.
48. $\frac{4}{9}$
49. 1.65
50. 11.5 c.cm.
51. 810 gm.
52. 1,108 lb.
53. 13.6

54. 20 in.
55. (a) 1,020 cm.
(b) 784.6 cm.
56. 2,700 ft.
57. 13.6 in., 2.3 cm.
58. 44.3 lb. per sq. in.
59. 2 atm.
60. (a) 26 in.
(b) 28.67 in.
(c) 71.4 cm.
61. 15 metres
63. 14.9 lb. per sq. in.
64. 352 ft.
65. (a) 75 c.cm.
(b) 20 in. mercury
(c) 20 c. metres
(d) 22.7 ft. water
(e) 90 c.in.
(f) 1,125 gm. per sq. cm.
66. $\frac{1}{2}$ atm. or 38 cm. mercury
67. 2 atm., 68 ft.
68. 30.9 ft.
69. 3 atm., $\frac{1}{3}$
70. 12.5 c.in.
71. 660 lb.
72. (a) $\frac{1}{8}$ atm.
(b) 2.45 lb. per sq. in., 550 lb.
73. 1,000 c.in.
74. 25.5 in.
75. 46.2 lb.
76. 0.8, 1.25
77. 12.3 cm.
78. Copper sulphate soln. $\frac{25}{24}$
79. 1.33
81. 0.96 gm. per c.cm., 33 ft. water
82. 7 sec.
83. 2.2 miles
84. 110 ft., 1,100 ft. per sec.
85. 1,150 ft.
86. 100 sec., 103 sec.
87. 1.5 km. per sec.
88. 384, 12
89. 1,437.5 ft.
90. 4.3 ft., 2.15 ft.
91. 460, 11 ft.
92. B
93. 238.1, 476.2
94. 9 in.



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